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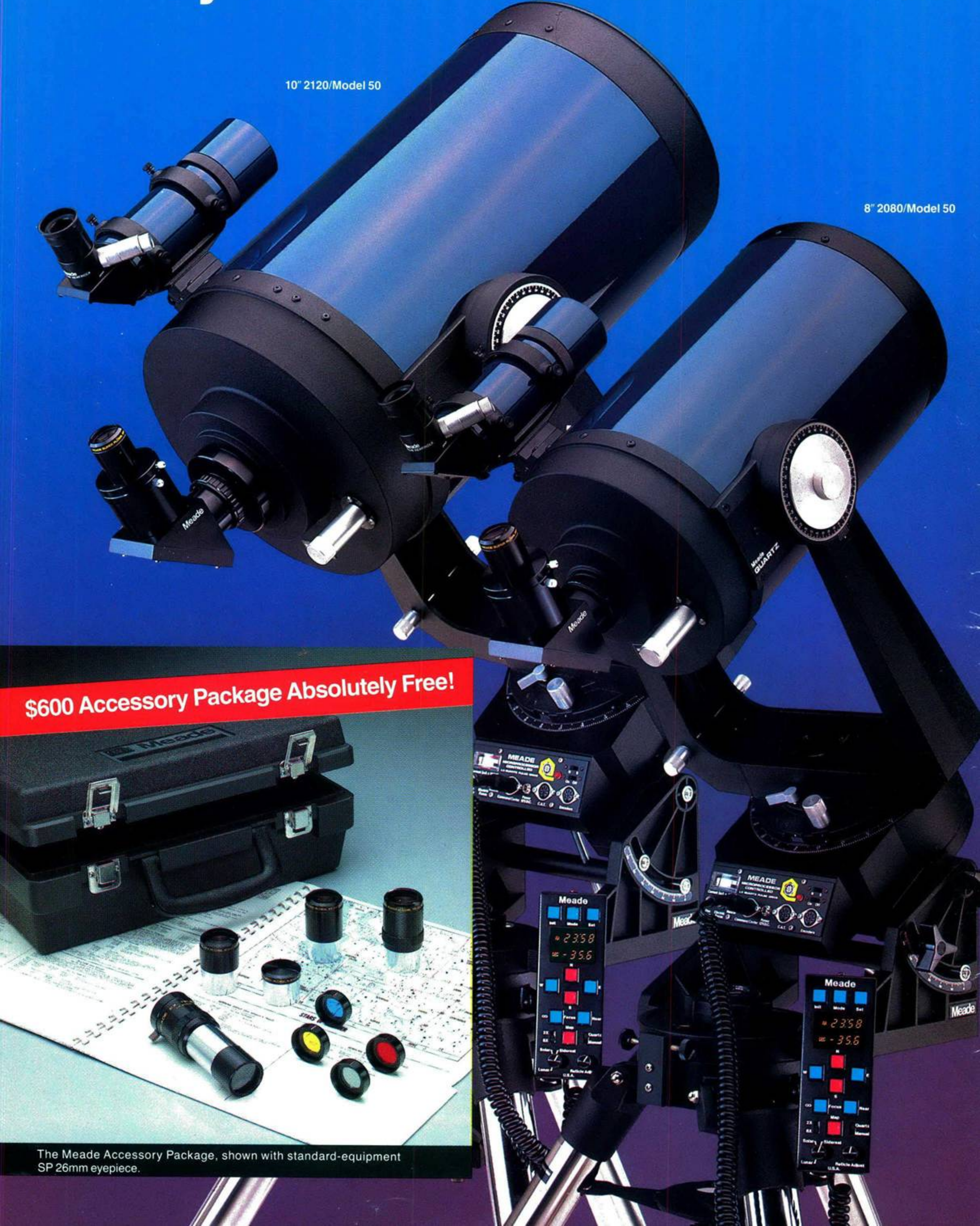
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The Meade Accessory Package, shown with standard-equipment SP 26mm eyepiece.

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3 We will ship direct to your door and **free of charge** the Meade Accessory Package described here (see inset photo, opposite page, and box, this page).

This offer is valid only for telescopes purchased ***between September 1, 1991, and December 31, 1991*** *and delivered in the USA and Canada. Registration Cards and invoice copies sent to Meade Instruments must be postmarked not later than January 15, 1992.*

All accessory components listed in the Package are the exact same, brand-new, premium-grade Meade accessories that we sell every day.

Regular retail value of the Meade Accessory Package, not including the value of the standard-equipment SP26mm eyepiece, is $618. (Telescopes are shown with optional Digital Readout System.)

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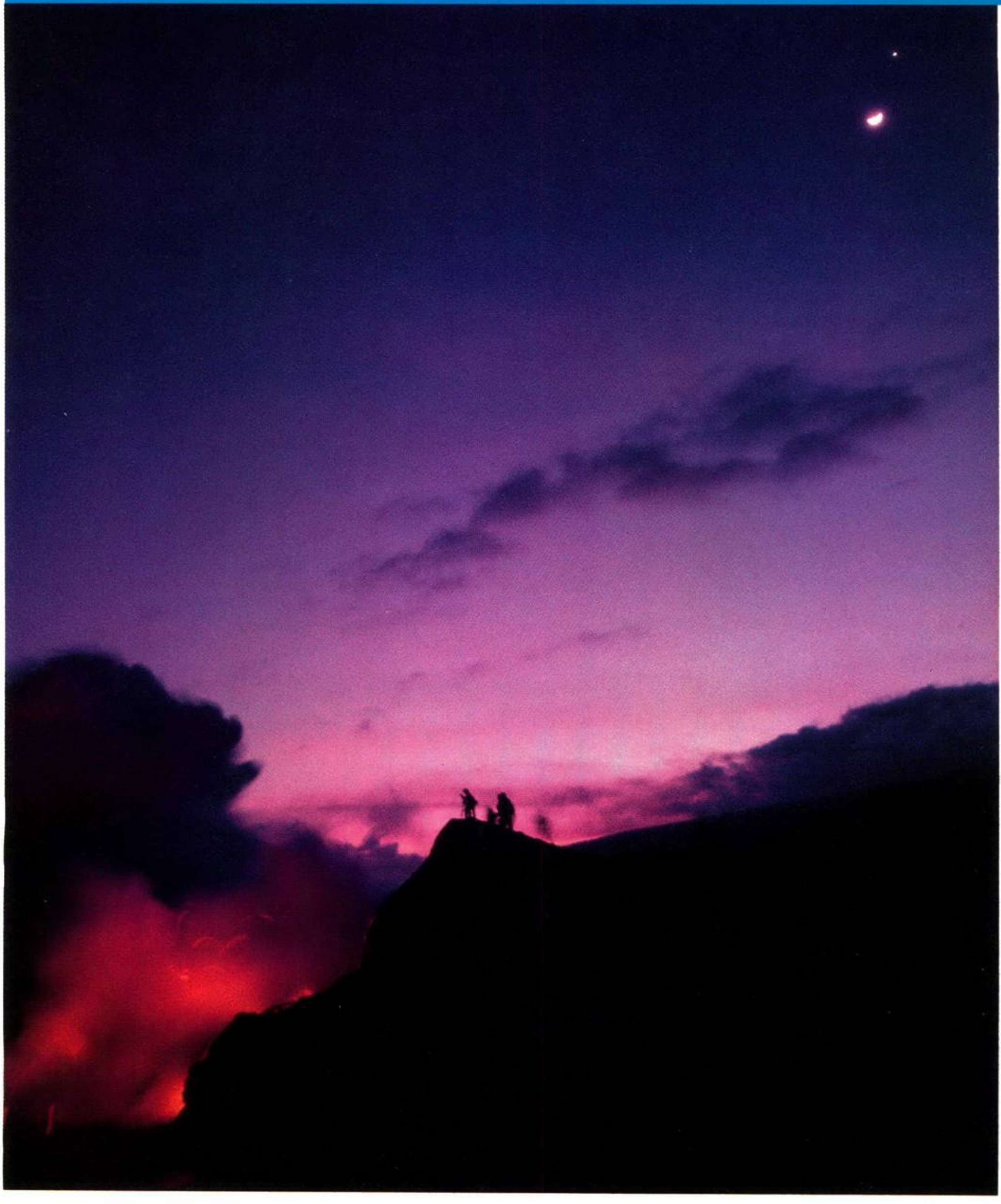
ON THE COVER: Jupiter posed for the Hubble Space Telescope's planetary camera last May 28. This photo, a composite of three filtered exposures, was taken to study the clouds and winds of this dynamic planet. Jupiter is now a bright object in the east during late evening. NASA photo.

THE ACTIVE EARTH AND THE QUIET SKY were the subjects of Paul J. Buklarewicz's photo from Hawaii taken on May 16, 1991. Billions of years ago, did volcanic activity such as this create the atmospheres of Mars, Earth, Venus (beside the Moon at the top of the photo)? Some scientists think not. See page 38 for the details.



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The
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Behind the Scenes

ONE DAY ON THE SUN

The Sun at the zenith last July 11 will remain burned into my memory for the rest of my life. The disk of the Moon was a black hole against the sky surrounded by a vivid glowing halo. Streamers and rays stretched outward twice, perhaps even three times, as far as I remembered from the 1983 eclipse in Indonesia. Six minutes and fifty-some seconds of totality passed in a flash. Then the corona was gone — only wonder and curiosity remained.

The scene now shifts to ASTRONOMY's offices one week later. As we examined the growing mountain of eclipse pictures, one question came up again and again: "Why did the corona look so huge, so bright, so . . . *different?*"

As the rest of us babbled excitedly, one voice remained calm and collected, that of associate editor David Bruning, ASTRONOMY's "new kid on the block." Dave knows the Sun; in fact, he's been a solar astronomer. He quickly saw patterns that the rest of us had missed. Rather than east-west, he said, the longest coronal streamers aligned north-south. Dave also suspected that coronal holes may have played some role in this highly unusual alignment — and so we asked him to research and write "One Day on the Sun," the feature story that begins on page 48.

Dave came to ASTRONOMY from the University of Louisville, where he worked as an assistant professor in the physics department and helped develop and expand the undergraduate astronomy program. As a professional astronomer, he studied surface motions and magnetic activity on Sun-like stars, and observed with the McMath solar telescope at Kitt Peak, the 100-inch Hooker telescope on Mount Wilson, and the 88-inch University of Hawaii telescope on Mauna Kea. He has also observed using the 4-meter Mayall telescope on Kitt Peak to measure stellar magnetic fields and, last November, the rotational speeds of white-dwarf stars.

Dave's love of astronomy dates back to sixth grade, when he entered a science fair project in astronomy. In high school, he built a telescope designed for solar observing and gave a two-week astronomy course for his fellow students that triggered his interest in teaching.

Dave will continue to teach, as an associate editor of our magazine, a class of 160,000 readers, directing his efforts toward making complex ideas in astronomy understandable and exciting for every reader. "What better place to be for sharing the marvels of astronomy with other people," says Dave, "than ASTRONOMY magazine?"

Sincerely,
Richard Berry
Richard Berry
Editor-in-Chief

ASTRONOMY

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Letters

What Are Those Almanac Symbols?

I am puzzled by some of the symbols on the Sky Almanac map found in the center of your magazine. I understand most of the symbols, but what are ϑ, ϰ, ϱ, π^3, o^2, L^2, and T.? What do the superscripts mean and what are these other designations? — *Richard Abshire, Pineville, Louisiana*

— Johann Bayer used the Greek letters to label the stars, usually in order of brightness, in each constellation. (Some constellations had the stars labelled in order from east to west.) Fo fainter stars that were important to the shape of the asterism and that had roughly equal brightnesses, Bayer assigned the same Greek letter and added the superscript 1, 2, 3, etc. We use script Greek letters in the Sky Almanac, so they may appear a little different than the Greek characters familiar to many of our readers. Fo example, ϑ is theta, ϰ is kappa, and ϱ is rho.

T. as it appeared in the Septembe Sky Almanac is a misprint. The do should be white — not black — since it is a star. The name of the star is Coronae Borealis and it is a variable star. Variable stars, unless they already have a Bayer Greek letter designation, are given capital Roman letters starting with R. This unusual choice o starting letters is related to the German word Rot*, which means red. Many of the first variables to be discovered were red in color.*

L^2 should be listed as L_2 in the map. The subscript distinguishes thi star from another nearby star called L_1. It too is a variable star but the capital L does not originally come from the star's variability. Nicolas Louis de La Caille used capitals in his 18th century catalog of southern stars.

I have a hard time interpreting the solar system map and relating it to the sky. Is it drawn for a particular time o the month? Is there any connection between the map and the moon phase icons below?

Also, I have a hard time reading the map under a red flashlight. Is there something that can be done so I can read the map more easily? — *Spenc Blakely, Portsmouth, Rhode Island*

Genesis Owner Turned Into Zombie!

Gentlemen:

I would like to say a few words about my new Genesis. I live in a relatively light polluted area, and own an 8" SCT which I have used for about two years. During this time there have been many deep sky objects which I have been unable to locate from my back yard.

I bought Genesis because I wanted a telescope that I could set up quickly to use at home on week-nights. When I began using Genesis, a few weeks ago, I was surprised to find many objects that have eluded me during the past two years. I was even more surprised when I realized that I had been looking in the right places all the time. These objects showed up in Genesis, but not in my 8" SCT.

My back yard experience with Genesis encouraged me to take it to my dark sky observing site which is, at an elevation of 5000 feet above sea level, in the Sierra Nevada Mountains. What I saw there was, in many cases, better than photographs in magazines. I was able to resolve globular clusters to a greater degree than publications indicate.

I didn't expect Genesis to be this good. It really is better than I imagined.

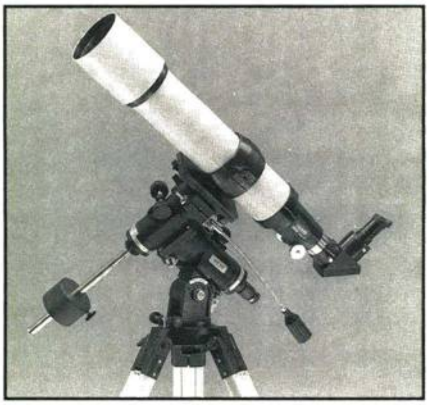
There does seem to be one problem with Genesis. My short week-night observing sessions have become anything but short, and I frequently arrive at work feeling and looking very much like a zombie. I guess that no telescope can solve all of your problems. In any case, thanks for the ones you did solve.

- George N. Storm, California

Photo by Jim Riffle

Unsolicited comments from warranty cards

- *It's beautiful, from case to scope.* C.C. The Netherlands
- *Fantastic! Great photo resolution, best optics ever owned and I'm a Hasselblad & Nikon fan. Now my best item.* D.B. New Jersey
- *This is my 1st scope and I'm having a wonderful time finding the limits of the instrument and my locating abilities.* G.P. New Jersey
- *Very pleased with your new improvements.* J.F. California
- *Even though cost was more than an 8" SCT with mount, quality & convenience won out. I will only use Tele Vue optics, mount and accessories.* W.B. Indiana
- *The telescope lives up to its expectation.* T.W. England
- *Wanted a 2nd telescope that was portable, delivered wide fields and superb images. Genesis is all I hoped for. The sharpness is astonishing and it's very portable.* G.H. Canada
- *Sold my 8" SCT looking for better images.* P.F. New York
- *Fantastic! My wife could not see Trapezium etc. with old scope. Now can't get her away from eyepiece: you have right to be enthused about your product.* W.J. Canada
- *I just wanted to have one excellent telescope to do astrophotography. Fantastic. Awesome.* J.J. California
- *Beautiful equipment - Total satisfaction with first use. Keep up the good work.* M.C. Ohio
- *I wanted a very high quality refractor. I was told by many - "This is it." This is a beautiful instrument!* M.F. Florida
- *Remarkable! I always wanted a 4" fluorite refractor. Sold my (8" SCT).* T.S. Indiana
- *Compactness & quality - a beautiful, fantastic instrument.* J.V. The Netherlands



- *It's the best 4" refractor made.* A.A. California
- *I was looking for the best first telescope I could buy. Something small. I never saw images clearer and more distinct than in Genesis.* G.D. Canada
- *Genesis is the only scope in the race. I wanted the best and believe I got it.* E.S. Australia
- *As the apparent equal of a (Maksutov), with the added RFT capability, Genesis is 'the', to me, obvious choice for portable astronomy. I'm completely satisfied.* R.A. Georgia
- *Very Impressive - my first view was of Pleiades with a 40mm Wide Field. The observation was remarkable, crisp, bright and jewel-like.* P.L. Massachusetts
- *The best on the market.* E.B. England
- *I bought this telescope without having seen it in-person, based on its specification & your reputation for quality. As usual, I got more than I expected with Tele Vue products...* K.L. Texas
- *My friend borrowed it & won't give it back!!* T.L. Canada
- *I wanted portability and very high quality optics. I have waited many years to be able to afford this telescope, - it was worth waiting for.* P.H. Australia
- *Superior to other 4" scopes on offer.* Z.V.S. South Africa
- *Had SCT, poor contrast/resolution. Tele Vue just the opposite, also it's more portable.* W.S. Connecticut
- *I purchased this instrument because:*
  1) Apo-refractor - basic design
  2) Tele Vue reputation
  3) Dealer owns same model
  U.B. Canada
- *Genesis is as good as gold...Maybe better!* F.G. California
- *I compared specs of Tele Vue vs (other high performance refractors); T-V best choice for $.* R.A. New Hampshire
- *Magic.* C.H. England

My sincerest thanks to all who've written us with such kind comments. I look forward to reading yours.

Al Nagler

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— *The planetary map is drawn so the Sun will appear at both edges of the map. The right side of the map shows the "evening sky" while the left side shows the "morning sky." Slow-moving planets like Jupiter have their apparent position in the sky marked by a dot. You should find the planet near this point in the sky all month.*

The faster-moving planets, the Sun, comets, and some of the brighter asteroids have their paths marked, with the direction of motion indicated by an arrow. The arrow's endpoints mark the object's position at the beginning and end of the month, while the dot indicates the object's position at mid-month.

The red, S-shaped line that nearly follows the ecliptic through the map is the Moon's path during the month. The map would be messy if we placed the lunar phase icons for each day of the month directly along the line. Instead, each icon is placed below the map directly under the Moon's position for that day.

The planetary map with its red printing isn't intended for use outside. Rather, its purpose is to show the positions of the planets with respect to the stars. The Star Dome is printed white-on-blue so you can use it outside to locate stars, constellations and the objects plotted in the planetary map. According to reports, most of our readers do not have trouble seeing the Star Dome under red light. You might have a problem with glare from your flashlight. Try illuminating the map from the side to reduce the glare. If that doesn't work, try photocopying the map. The grayish tones of the copy might be easier for you to see under a red flashlight.

Eclipse Photo Request

My family and I will never forget our view of the July 11 total solar eclipse from the cruise ship *El Sarape* (out of Puerto Vallarta). Now that we're home, it's impossible to describe totality to people who saw only the partial phases of the eclipse. I had hopes of getting some great photos, but I came home with only memories, thanks to a loose screw in my camera.

I regret not having asked anyone else for copies of their photos while on board the ship. If anyone who was aboard *El Sarape* has some pictures of totality that they would be willing to share, please contact me. (I'll be willing to pay for the cost of the reprints and postage, but please write first.) Thanks!
— *Ronnie Seagren, 11424 West Ida Avenue, Littleton, Colorado 80127*

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Another View of the Eclipse

Totality was 550 miles south of my home, so a friend and I drove down to enjoy the show. Our viewing site was on the side of the main highway to Guadalajara. We were lucky! Heavy clouds were visible in all directions except towards the eclipsed Sun.

I also thought it was interesting that many cars and trucks (with headlights on) kept going on their way during this event of a lifetime. I expected that someone would stop to look at the eclipse, but no one seemed to care. Except for my friend and myself — we were celebrating! — *Daniel Schmidt, Pearsall, Texas*

January 4, 1991 Annular Eclipse

The sunset annular eclipse has the potential to produce some unusual atmospheric phenomena. If the California coast is clear of haze and fog, the conditions will be good for viewing the elusive green flash. The green flash occurs when the last bit of the setting Sun breaks into a spectrum of colors. Reddish colors are hidden by the horizon and blue is scattered by the atmosphere, so the Sun appears green. You may be able to see two flashes as each of the cusps of the eclipsed Sun sets. Also, look for peculiar shadows of objects cast by the Sun during the deep partial phases and annular portion of the eclipse.

Observers at higher altitudes may be able to watch the Moon's shadow approach from the ocean toward the onset of annularity. If you look east, away from the setting Sun, you may see the Moon's shadow (and possibly Earth's) projected on the atmosphere. — *Stephen Edberg, La Canada, California*

June 30, 1992 Eclipse Preparations

We are making all of the necessary arrangements to provide assistance to people who might want to travel to Uruguay to observe the June 30, 1992 total solar eclipse. For further information, contact me at: Comisión del Eclipse Total Solar, Comité Nacional de Astronomía - Ministerio de Educación y Cultura, Casilla de Correos 14.020, Montevideo, Uruguay. Our FAX number is 011-598-2-487388. — *Javier Licandro*

Exploring the Sky with a Computer

I recently used the computer program Dance of the Planets and "discovered" an upcoming celestial event that must be both rare and beautiful. On the morning of April 23, 1998, the Moon will occult both Venus and Jupiter at the same time. The occultation will be seen from the south Atlantic Ocean and parts of Africa and India.

I'm certain that I am not the first to notice this event, but I've never seen any mention of it. How rare is an occultation of two planets? — *David Bryant, Agoura Hills, California*

— A table of occultations is given in Jean Meeus' book Astronomical Tables of the Sun, Moon, and Planets. *It is not uncommon for two planets — such as Uranus and Neptune — to be occulted on the same day, but the occultations are usually several hours apart, making them disappear singly. Two planets being occulted at the same time is less common but isn't extremely rare. Another simultaneous disappearance will occur on March 4, 2000, when the Moon occults Venus and Uranus. Another interesting event to explore with your program is the occultation of a planet at the time of a lunar eclipse. One example is the occultation of Neptune on July 28, 1999.*

Small Star Parties Are Fun!

You always report on and emphasize the large star parties. But smaller events also have a lot to offer. The Third Annual Northwoods Starfest was held August 16-18 in Fall Creek, Wisconsin. With fifty to sixty people attending on Friday and Saturday nights, it was not the largest amateur gathering. However, the meeting was still informative and exciting.

On Saturday afternoon, many of the amateurs attending gave informal presentations on their latest software, hardware, or techniques for observing the universe. One of the highlights of the starfest was the mobile observatory owned by Bill Volna of Minnesota.

With a smaller event, it is easier to get to know and learn from everyone in attendance. This more personal approach to astronomy has many advantages not available at some of the larger, well-known star parties. I hope you will check out one of the smaller star parties near you. — *Gary Baier, Chippewa Falls, Wisconsin* □

ASTRONOMY welcomes comments, suggestions, and additional information on articles and astronomy in general. Send your letters to: ASTRONOMY Letters, P.O. Box 1612, Waukesha, WI 53187. Letters may be edited for length or clarity.

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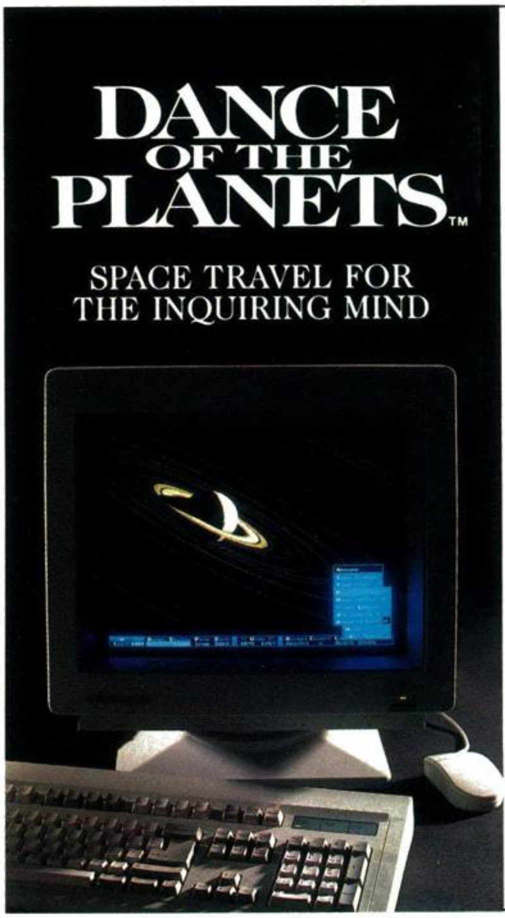

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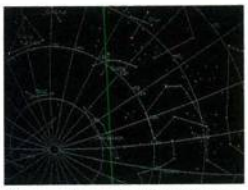

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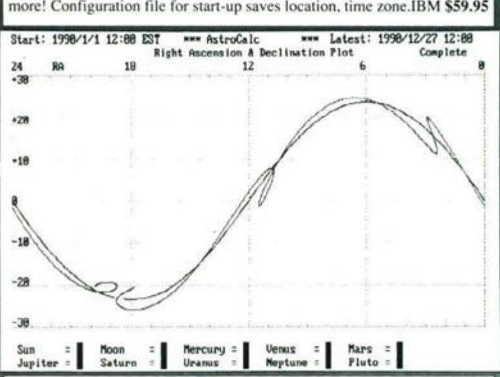

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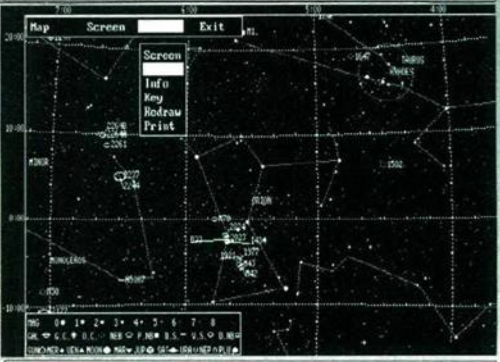

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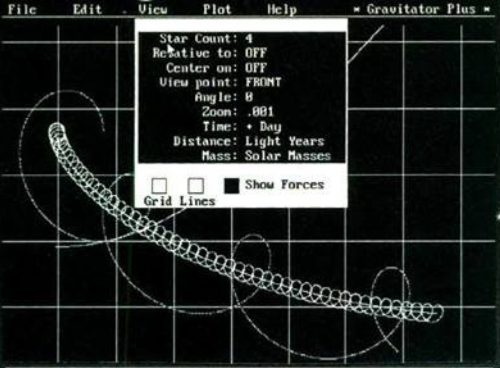

```
Star Count: 4
Relative to: OFF
Center on: OFF
View point: FRONT
Angle: 0
Zoom: .001
Time: • Day
Distance: Light Years
Mass: Solar Masses
```

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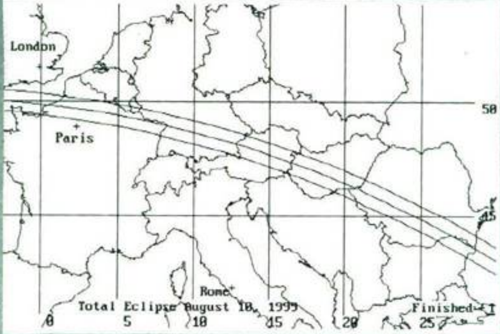

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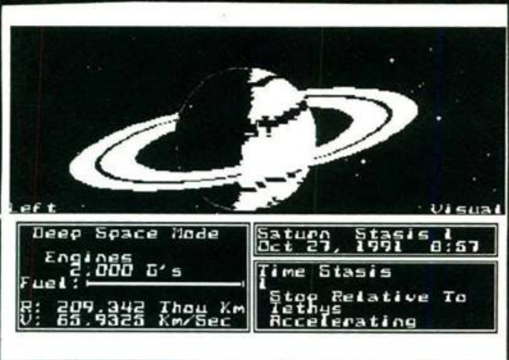

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Deep Space Mode
  Engines
   2.000 G's
Fuel:
R: 209.342 Thou Km
V: 65.9325 Km/Sec

Saturn    Stasis 1
Oct 27, 1991   0:57

Time Stasis
1
 Stop Relative To
 Tethys
 Accelerating
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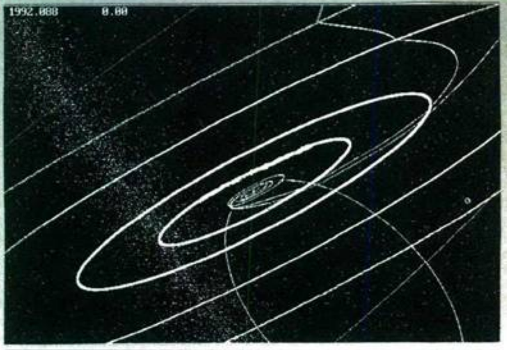

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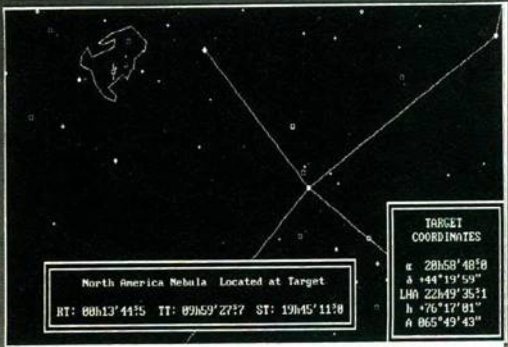

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North America Nebula  Located at Target

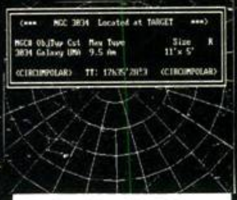
RT: 00h13'44:5  TT: 09h59'27:7  ST: 19h45'11:0
```

```
TARGET
COORDINATES

α  20h58'48:0
δ +44°19'59"
LHA 22h49'35:1
h +76°17'01"
A 065°49'43"
```

Add Your Own Objects, w/ Names and Detailed Images

Mars in Retrograde



```
(***   NGC 3034  Located at TARGET   ***)

NGC# ObjTyp Cst  Mag Type           Size    R
3034 Galaxy UMA  9.5 Am            11'x 5'

(CIRCUMPOLAR)  TT: 17h35'20:3  (CIRCUMPOLAR)
```

Find or Identify Objects

☐ RA & Dec Grids, Add Your Own Notes!

Display options include grid lines plotted that show the place in the sky (right ascension & declination), or grid lines can be disabled. By zooming in or out you can get views or charts at any scale you need! You can add notes (text messages) to the displays so that printouts can have labels you wish to add for customization.

☐ Optional 259,075 SAO Star Database

Use the large star database to get all stars down to 11.9 mag. for detailed charts or views of the sky. Or create smaller databases in 8 different sizes. Besides graphical plots, the SAO database will give you a large reference set of star data using the Find function.

☐ Plotting Mode, Constell. Boundaries

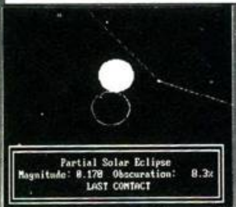
The plotting mode will plot the paths of Sun, Moon or planets on the display. Easy way to record the track of an object. Another option is to plot the boundaries of each constellation. Then you can immediately know in which constellation any star, deep-sky object or planet is located.

☐ Video Mode to Record and Play Back!

A Video mode provides the ability to record and save the screens calculated by LodeStar. You can then play, pause, stop or rewind. Get slide shows for demonstrations or teaching astronomy. Show it all, with LodeStar Plus II!

☐ Complete Deep Sky & Star Databases

Includes all 7840 NGC objects, the most important galaxies, star clusters, bright nebulae, planetary nebulae, etc. Display on screen or printed charts. Find or identify any of the 7840 objects, 9100 stars(or SAO database) or planets. All Messier objects included as a separate set. Stars include SAO numbers and HD numbers and other info for complete identification.

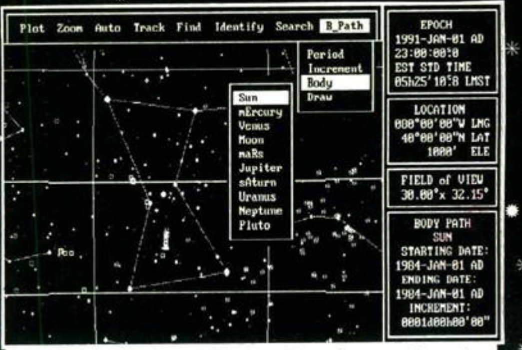


```
Partial Solar Eclipse
Magnitude: 0.170  Obscuration:   0.3%
LAST CONTACT
```

Solar/Lunar Eclipses

```
Pollux  Located at Target
```

Find Objects by Name



```
EPOCH
1991-JAN-01 AD
23:00:00:0
EST STD TIME
05h25'10:8 LMST

LOCATION
000°00'00"W LNG
40°00'00"N LAT
1000'  ELE

FIELD of VIEW
30.00°x 32.15°

BODY PATH
SUN
STARTING DATE:
1984-JAN-01 AD
ENDING DATE:
1984-JAN-01 AD
INCREMENT:
0001d00h00'00"
```

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LodeStar Plus, similar to Plus II, but lacks these features: Has standard 9000 star database but can not use optional large SAO database and not able to add user objects and images. **$149.95**

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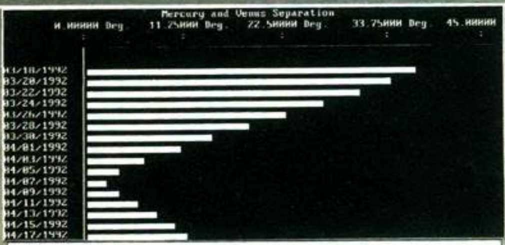
"LodeStar Plus improved greatly my perception of the sky, excellent program!" - F.B., Las Cruces, New Mexico
and many more positive evaluations of LodeStar Plus.



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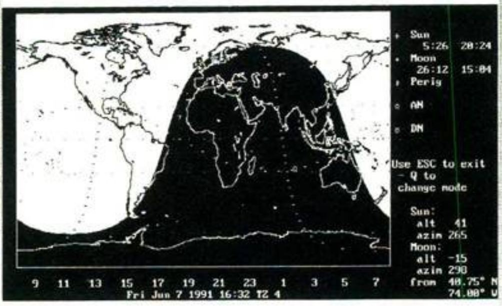

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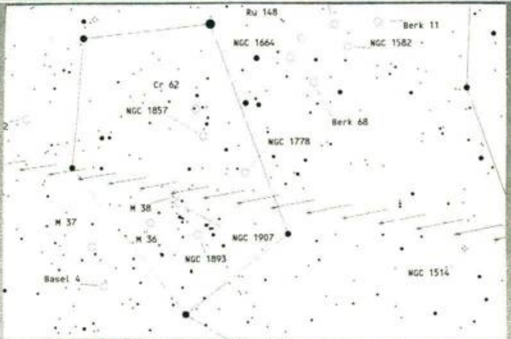

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Viewpoints

CHIPPING AWAY

by John C. Vickers

Looking up at the darkening sky, I see that the party is "Go" for this evening.

What used to be an intimidating list of camera setup procedures and operational steps I have now pared down to an automatic routine. I methodically don proper attire, pull the Mac, keyboard, and mouse from their peripherals, and lug them up the many well-trodden steps from the basement office to the 4th-floor observatory.

Planetary nebula NGC 2438.

("Can't wait for one of those cheap Mac clones," he grumbled audibly into the dimly lit stairway.)

The computer slides into its slot under a small color monitor, next to the CCD computer and gray-scale monitor. All this is protected from moisture and cold with a low-tech but effective plastic housing that also permits alternate viewing and dimming of control panels — no more light leaks or dark-vision loss for me. A few quick hookups link the components, a hair drier (my CPU-Environmental Stabilizer) temporarily warms the computers, the CCD loop is toggled up — and awaaaay we go!

In 20 minutes or so the CCD camera temperature stabilizes at least 50°

C below ambient conditions. The colder it gets outside, the better for the chip. During this time the dome and telescope also cool off while I acquire and focus the optics on the night's first quarry.

A 4- to 15-second integration through the 14-inch instrument at f/11 will show on the screen — clearly if coarsely — any object that I'm seeking. If I weren't trying to squeeze the observing juice out of every target I find, this system could let me effortlessly swoop up in a single night several hundred objects (plus a good piece of a gigabyte of memory).

Ah, CCD astrophotography! No careful measures to maintain dark-adapted eyes. No fussy object repositioning, no tricky long keyboard commands in the dark with gloves on — a single macro command does everything from camera prep to archiving.

Imagine, two new images showing magnitude 16 or fainter stars flashing across the screen every single minute of the night. Some intrepid aficionados have even automated the human role right out of the process except for analyzing the data. But I'm comfortable with my deliberate plod.

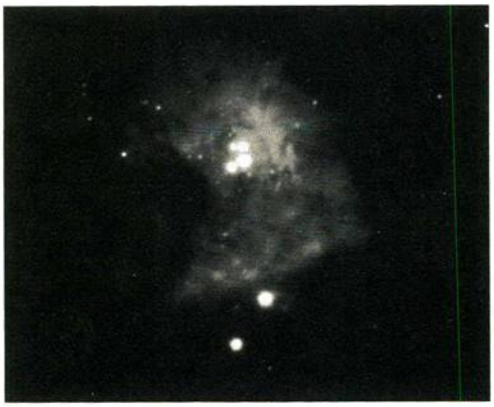
I always hug the meridian. Being at sea level, I figure I'm looking at stars through enough atmosphere as it is. Focusing is . . . well, a bit of a pain. I find a field with a few stars (about magnitude 12) barely showing on a one-second exposure. I make small focus changes back and forth in a sequence of frame integrations until the stars are as small as they get.

Now we — the CCD and I — are ready for work. I recenter the object and the fun part starts. With trepidation, I peek into the off-axis guider. Will there be a happy little guide star in there to greet me? Or will I spend the next 15 minutes tracking down some feeble blur, while relegating the object to a corner of the frame? Very faint guide stars vanish as they enter the weak red glow of the reticle, so I slyly place one as close as possible to an outer corner of two reticle wires and then do my best to "park" it there.

A star now resides near the crosshairs and I bump the power up to 1080x. Now I can tell if that baby moves, and move it will. A few quick keystrokes and the CCD array is read out for bias, clearing it of charge. I set the integration time, dim the screens, and eyeball the guide star for movement. Then I tap the return key blindly and hear the *click!* of the shutter.

Let conventional astrophotographers weep: my exposure times vary from 30 seconds in which to grab a flashy open cluster up to 6 or 7 minutes for faint details. The lower limits to useful exposures are determined by sensitivity and readout noise, while the upper limits are set by properties such as dark current at a given device temperature, pixel saturation charge (the full-well capacity), and the maximum number of gray levels converted from the chip's analog signal into digital computer data. (You got that?)

Let's imagine we've just touched off an exposure. In unison, a quarter-million sensitive little CCD pixels begin quaking in response to a wide range of light at 20 times the rate of most films — and they don't poop out, either. Twice the exposure generally yields twice the signal strength. As the moments tick by, you concentrate on the guide star; Topgun pursues his hapless mark relentlessly.



The core of the Orion Nebula, M42.

In the background, two computer CPUs with fans and one hard disk whirl away. The two monitors barely hum, the scope electronics do a dull buzz, and although occasional sea breezes whoosh over the dome, the apparently preoccupied guide star is unperturbed. Who needs a radio?

Speaking of noise, there are a few drawbacks. Dark current builds up over time across the CCD pixel array, but it can be corrected to a certain extent by taking dark exposures. These are frames of equal time and temperature as the exposure but with the shutter closed. Averaging many dark frames improves accuracy at the expense of

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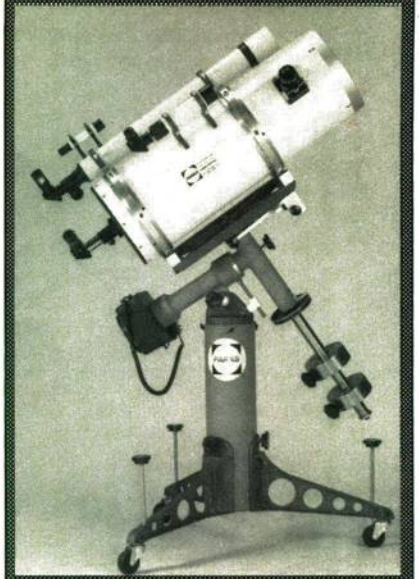

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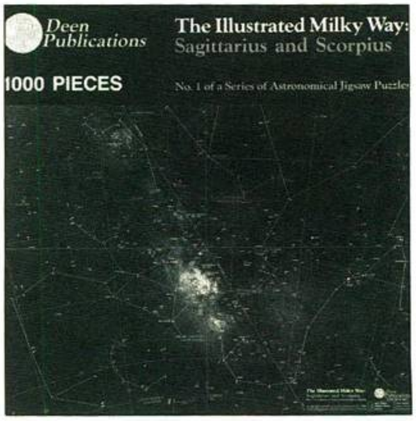
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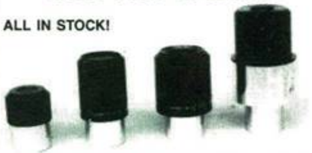

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ASTRONOMY February 1991

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Rich Zepernick saw the Veil Nebula for the very first time with a **LUMICON UHC Filter**. He stated, *"It was actually there! and not just around 52 Cygni, but the whole loop! Words cannot possibly express my feelings. I don't know how I managed without these filters."*
Rich Zepernick, Cresskill, NJ

SEE THE HORSEHEAD!

Horsehead Nebula in Orion. This faint nebula is seen best with a LUMICON H-Beta Filter. Photo by J. Marling using a Deep-Sky Filter.

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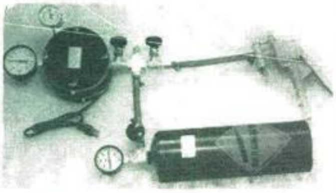
LUMICON HYPER-KITS™ yield 3-15x film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

U.S. Patent 4,473,636

MAKE YOUR OWN HYPERED FILM

MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$325**



MODEL 600 HYPER-KIT (See photo) Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$395**

MODEL 1200 HYPER-KIT is for 4X5" plates and film up to 5X7". Has 2 gas cylinders and includes temperature controller ... **$595**

Temperature controller for any HYPER-KIT **$65**

Electric Vacuum Pump, Model R-10 **$325**

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms for bright guide-stars.
Specify Camera and Telescope type.

U.S. Patent 4,448,500

NEWTONIAN EASY-GUIDER™

Full aperture. Installs in seconds. Specify 2" or 1¼".

NEWTONIAN EASY-GUIDER **$169.50**
3X Relay Diagonal (see photo) **$89.50**
Illuminated reticle eyepiece system .. **$99.50**
Guider for Hasselblad **$350,** Mamiya 645 **$199**
Pentax 6X7 **add $119;** Pentax 645 **add $139**

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Cynamax-8. Includes 50mm achromatic lens for f/5.8 operation—3X shorter exposures! **Superb rich field viewing, too!**

CASSEGRAIN EASY-GUIDER **$225.00**
Adapter for Hasselblad **$198,** Mamiya 645 **$98**
Pentax 6X7 **add $119;** Pentax 645 **add $139**

GIANT EASY-GUIDER™

For Celestron-11, C-14, and the 10" Meade 2120. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

GIANT EASY-GUIDER **$395.00**
48mm DEEP-SKY Filter ordered with any
EASY-GUIDER (SAVE $20) ..... **add $99.95**
Adapter for Hasselblad **$229,** Mamiya 645**$129**
Pentax 6X7 **add $129;** Pentax 645 **add $149**

WHAT DO YOU NEED?

1. Illuminated reticle eyepiece **$99.50**
Lumicon 12mm eyepiece system has adjustable LED illumination, dual crosslines, battery pack.

2. *Cable release* for long exposures .. **$9.95**

3. **LUMICON Quartz Drive Corrector . $219**
Dual-axis drive corrector is essential for astrophotography and/or field use of your telescope. 40Hz/80Hz variable output controls telescope drive. 60Hz Quartz reference ±12VDC Declination control output. Both 110VAC and 12VDC input for home or field use. Declination reverse switch for Newtonians.

Declination motor (state telescope) .. $99
NEW Deluxe Digital Qtz. Drive Correc. **$298**

Kodak
SR1600
Scotch
Scotch
1000

HYPERSENSITIZED FILM

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. Deduct 10% for 3 or more rolls (mixed o.k.).***No C.O.D.s.***

Film Type, 35mm	Exposures	Price
2415, Ultra-fine B&W, red sens.	36	**$10.95**
SR-G3200, fastest of all, color neg	24	**$13.95**
Kodak Ektar 1000 fast, fine grain	24	**$12.95**
Fuji HG400 fine grain color neg.	12	**$10.95**
3M 1000, fastest slide film	12	**$12.95**
Fujichrome RD100, fine grain slide	24	**$12.95**
D-19 B&W Developer	1 gal.	**$6.95**

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NEW LOWER PRICES — NEW HIGHER PERFORMANCE — LUMICON® SKY VECTOR™

SKY VECTOR™ $399

LUMICON SKY VECTOR FEATURES:

- Digital right ascension readout to 1 minute of right ascension (RA)
- Digital decl. readout to 10 arc-min
- 4000 pulse (0.09° accuracy) high resolution encoders
- Polar alignment ***not required!***
- Motor drive ***not required!***
- Just sight two stars to align!
- Works **equally well** for alt-azimuth telescopes like Coulter Odyssey and equatorial mounts like C-8, Meade 2080.
- **No need** to enter latitude, longitude, date, sidereal time, etc.
- 9V Battery lasts many nights.

Each LUMICON SKY VECTOR™ includes one computer with digital readout, two precision high resolution digital shaft encoders, connecting cables, & mounting hardware (for most popular telescopes). **Specify telescope.**

LUMICON SKY VECTOR™ for Meade 2045B, 2080, 2120 *(Specify)*	$399
For Celestron C-8, C-11 *(Specify)*	$399
For Coulter Odyssey 8", 10", 13", 17½"	$399
For any alt-azimuth (Dobsonian) scope	$399
For Celestron C-14 (rewire dec. motor)	$498
SKY VECTOR KIT (for skilled ATM's)	$369

Reference catalogues (1000's of objects)

Burnham's *Celestial Handbook*, I, II, III	$36.85
Revised New General Catalogue (all NGC and IC, Epoch 1975.0)	$35.00
Sky Catalogue 2000.0, Vol. II	$29.95

SKY VECTOR II™ $499

Only the LUMICON SKY VECTOR II has size, **true visual magnitude**, and complete **detailed visual description** for **all** 1500 objects in memory.

OFF ON
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1735+273
RA
DEC
MODE
STAR
UP
DOWN
Sky Vector II™
COMPUTER SETTING CIRCLES
LUMICON®

LUMICON SKY VECTOR II™ Computer with 1500 object memory, digital readout of coordinates, easy-to-use controls, object size, visual magnitude and detailed visual appearance descriptions.

Please specify telescope type:

LUMICON SKY VECTOR II™ for Meade 2045B, 2080, 2120 (*Please specify)*	$499
For Celestron C-8, C-11 *(Specify)*	$499
For Celestron C-14 (rewire dec. motor)	$575
For Coulter Odyssey 8",10",13"17½"	$499
For any alt-azimuth (Dobsonian) scope	$499
SKY VECTOR II (upgrade, computer only)	$395

The **LUMICON SKY VECTOR II™** has all the features of the regular SKY VECTOR, but has 1500 of the best deep-sky objects in memory, selected by noted observer Steve Gottlieb, along with their coordinates, size, true visual magnitude, and complete detailed visual descriptions. The sophisticated computer programming also will guide you to the object selected by displaying the real-time angular separation. Just move the telescope until the angles displayed become "0" using the "GUIDE" mode.

LUMICON SKY VECTOR II FEATURES:

- Includes **size, true visual magnitude & detailed visual appearance description** for all 1500 objects
- All 110 Messier objects
- Brightest 31 alignment stars
- User definable catalogue of 25 objects retained in memory
- 703 galaxies, groups & clusters
- 228 best open star clusters
- 170 best planetary nebulae
- 77 emission & reflection nebulae
- 10 best dark nebulae
- 107 best gobular star clusters
- 205 best colored & multiple stars
- Displays Uranometria 2000.0 chart no.
- ROM upgradable for planets, extended object lists, etc.
- TIMER function, elapsed time & stop watch
- 2 star alignment for alt-azimuth or equatorial telescope systems
- 1 star alignment if polar aligned
- Uses Epoch 2000.0 coordinates
- May align on any of the 1500 objects in memory

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1528 Additions / Corrections

NGC-Sky Vector
OFF ON
DIM
GUIDE
ENTER
UP
DOWN
LUMICON

Improved NGC SKY VECTOR with over 8,000 object memory including complete and corrected RNGC catalogue, and IC and planetary catalogues.

LUMICON NGC SKY VECTOR FEATURES:

- All features of LUMICON SKY VECTOR II
- Complete *corrected* RNGC catalogue
- 574 nonexistent NGC objects identified
- 343 corrections to RNGC catalogue
- 203 best colored & multiple stars
- 140 "Best IC Objects" catalogue
- 306 best planetary nebulae selected by Jack Marling in separate catalogue listing
- 268 best "Non NGC/IC" objects catalogued
- "IDENTIFY" program helps you identify an unknown object seen in eyepiece
- "GUIDE" program leads you to object
- Detailed visual or photographic descriptions
- RS-232 port for computer access
- Includes planets ephemeris in computer

LUMICON NGC SKY VECTOR for Meade 2045, 2080 or 2120 *(Specify)*	$699
For Celestron C-8, C-11 *(Specify)*	$699
For Celestron C-14 (rewire dec. motor)	$775
For Coulter Odyssey 8",10",13",17½"	$699
For any alt-azimuth telescope	$699
NGC SKY VECTOR (upgrade, computer only)	$550

MEADE® TELESCOPES

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LUMICON ACCESSORIES

NEW PREMIER SERIES TELESCOPES

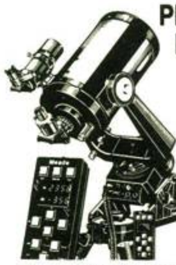
All Meade Premier Series telescopes **include Smart Drive (SD) permanent periodic error correction,** multi-coated enhanced optics (MCOG), Electronic Command Center (ECC), and **include** advanced LX6 all-electronic drive system. Select f/10 or f/6 optics, and select only the optional features you **need.** The 8" has a 6X30 finderscope and the 10" has an 8X50 finderscope. SD = Smart Drive.

2080 Model 40SD, 8" f/10	**$1650**
2080 Model 46SD, 8" f/6	**$1799**
2080 Model 50SD, 8" f/10	**$1950**
2120 Model 40SD, 10" f/10	**$2150**
2120 Model 46SD, 10" f/6	**$2298**
2120 Model 50SD, 10" f/10	**$2450**
Model 2600 16" f/10	**$10,950**

Options Enhance Performance

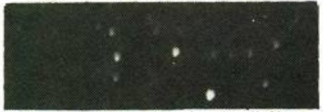
Super Wedge for 10"	**Add $299**
#39 Declination motor	**Add $109**
Digital setting circle	**Add $399**
2" Star diagonal	**Add $179**
LUMICON Cassegrain Easy-Guider *(Please specify camera)*	**Add $225**
LUMICON Giant Easy-Guider (for #40) *(Specify camera)*	**Add $395**
LUMICON Giant Easy-Guider (for #46) *(Specify camera)*	**Add $295**

PREMIER 2080
Model 50SD
$1950

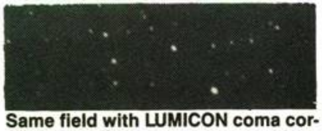


Meade Premier 2080 Model 50SD

COMA CORRECTOR



Coma 1 inch off-axis 17½" f/4.5



Same field with LUMICON coma corrector; smaller, more numerous stars.

This computer-designed LUMICON 2" lens reduces coma and flattens the field for both viewing and photography. It threads into LUMICON 2" EASY-GUIDERS for effortless installation. This lens is optimized for f/4.5 and reduces aberrations for f/3.5 to f/5 Newtonians. Off-axis images are much smaller, making off-axis guiding far easier and yielding round pinpoint star images in photos. Since star images are sharp over a full 2¼" circle, you can use medium format cameras in addition to 35mm cameras. This zero power lens does not change image scale nor shift focus, and all lens surfaces are multi-coated for highest efficiency. Although designed for photography you may also use this lens to improve image quality in wide-field viewing with low power eyepieces. Clear aperture = 1.8".

LUMICON Coma Corrector/Field Flattener Lens	$285.00
LUMICON 2" EASY-GUIDER	$169.50
2" EASY-GUIDER (Mamiya 645)	$199.50
2" Adapter for Pentax 6x7	$85.00
2" Adapter for Hasselblad	$185.00
2" Adapter for Bronica SQ-A	$175.00
2" Extension for viewing	$26.00

2" DELUXE BARLOW

1.8x Multiplier Lens

The computer-designed LUMICON 2" Multiplier/Field Flattener multiplies the image scale in photography by 1.8x (f/4.5 becomes f/8). Use it with any LUMICON 2" EASY-GUIDER. Guide-stars also become much sharper to make guiding easier. This lens is optimized for f/4.5, but will work well with any optical system. It may also be used visually as a highly corrected 2" Barlow lens.

LUMICON 1.8x Multiplier Lens	$235.00

NEW! LOW PROFILE HELICAL FOCUSERS

FROM
$59.50

LUMICON® LOW PROFILE FOCUSERS

LUMICON now offers 3 different low-profile helical focusers. They stand only 1¼-1½" above the telescope tube. Use the 1¼" or 2" versions for viewing. Use the 2" non-rotating focuser for convenient photography with the LUMICON 2" EASY-GUIDER™.

Select your desired base-plate shape!
Flat, 7" OD, 9½" OD, 12½" OD, 16" OD, 21" OD.

LUMICON 1¼" Helical Focuser	$59.50
LUMICON 2" Helical Focuser 1½" high	$65.00
LUMICON Non-rotating Helical Focuser	$89.50
2" rack & pinion focuser, only 2" high	$139.00
3 handles for non-rotating focuser	$12.95
2"/1¼" **adapter** w/48mm filter threads	$20.00
2" LUMICON EASY-GUIDER	$169.50

LUMICON 50mm, 80mm SUPER-FINDER™

Visual Astronomers prefer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F=300mm coated achromat or 50mm, F=200mm coated achromat. Eyepieces and/or star diagonal are extra.

1¼" 50mm Finderscope **$59.50**, right-angle	**$89.50**
1¼" straight-thru 80mm SUPER-FINDER	**$169**
1¼" right-angle 80mm SUPER-FINDER	**$179.50**
1¼" right-angle version, w/star diagonal	**$209**
25mm Cross-hair 1¼" eyepiece (12X)	**$39**
1¼" Star Diagonal **$39**, Mounting Brackets,	**$37**
1¼" Amici Prism diag. for correct left-right views	**$69.50**

2" ADAPTERS MEADE, CELESTRON TELESCOPES

These adapters convert refractors and Schmidt-Cassegrain telescopes for 2" operation. They allow use of 2" accessories, such as the LUMICON 2" EASY-GUIDER for photography. They also allow use of 2" eyepieces and/or 2" star diagonal for viewing.

2" adapter for C-8, Meade 2080, etc.	**$26.00**
2" adapter for C-80, C-100 refractor	**$39.50**
2" adapter for C-70, C-80F, C-90F, C-100F	**$39.50**
2" Accessory adapter for Comet Catcher, C-6, Meade 312, 321 refractor	**$30.00**
2" LUMICON EASY-GUIDER (state camera)	**$169.50**

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Your low cost alternative digital weather station, offers 16-point LED compass display Wind Direction Monitor, digital wind speed (MPH) and temperature (°F) display. With optional car lighter power cord and suction cup mount, the **WS100** can be operated anywhere. Constructed of clear acrylic, the system includes: 40' cable, waterproof temperature probe with 7' cable, power supply and operating manual.

The **WS101C Weather Center** combines the **WS100** sending unit with *IBM compatible software/hardware; provides graphic display and history* plots, wind chill, max/min values and alarms. **Complete system for only $179.94 (+ $4.00 shipping).**

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- **WIND-TECH 1000 Hand Held, Digital Anemometer** $59.95 (+ $3.00 shipping)
- **TEMP-TECH Digital Thermometer with 7' Waterproof sensor** $27.95 (+ $2.00 shipping)
- **Car-Top, Suction Cup Mount for WS100 Sending Unit** $15.95 (+ $2.00 shipping)
- **Car Lighter Power Cord for WS100 Console** $5.95 (+ $1.00 shipping)
- **Custom Cable Lengths for WS100 and Temp Probes available**
- **Metric Conversion (°C/meters per sec)** $9.95
- **Extra WS100 sending unit** $49.95 with purchase of complete system *$59.95 without* (+ $3.00 shipping)
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productivity. But dark frames, duplicate object shots, focusing, and acquiring flat-field integrations — to compensate for optical and CCD sensitivity variations across the field — all translate into fewer shots per turn of Mickey's big hand. And don't forget about the hefty set-up and breakdown time of this equipment.

When I envision someone dragging all this rigamarole out to a mountain site, I start to chuckle. You know, the CCD may finally give back a bit of ground to those frustrated individuals with modestly located home observatories. Take that, you dark-sky startrekkers!

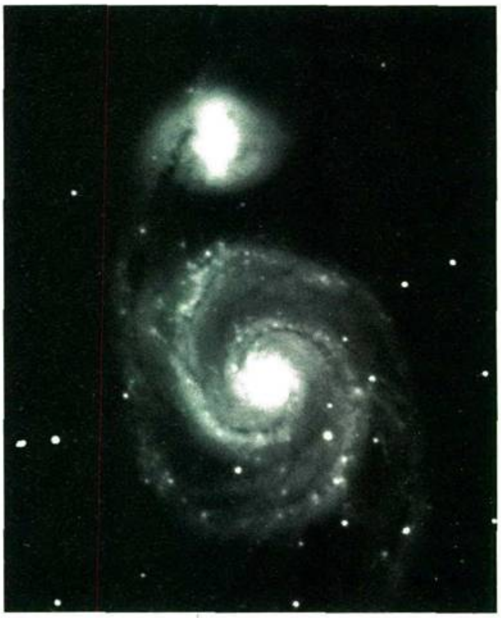
Oh, yeah, remember that exposure we started? Finally, I hear the wonderful second *click!* that signals the end of the exposure. A few seconds elapse while all those pixels are shifted, sampled, read out, digitized, downloaded to the CPU of the CCD, and transferred to the video bus for display. No matter how many shots I take, I gasp as each new one flashes up on the screen, fresh from the silicon. TOTALLY INCREDIBLE! With the monitor I quickly check the guiding and overall appearance and then instruct the Mac to save the photo to disk, a process requiring several more seconds. Next, I immediately reshoot the picture or move on to the next gem.

The megabytes add up on the hard drive. Occasionally, I check the thermometer to ensure the computer is operating within its specified range. (Wish *I* were — it's cold in the dome.) I check the optics for dew or frost, take another dark frame, shift the dome a bit, refocus. . . . Hey, I even look up once in a while. It's amazing some of the things you can see when you do that.

By the end of a session, I may have 30 to 40 deep exposures archived that will eventually be compressed in size. Mustn't forget to backup the drive as soon as possible; I know firsthand what an ill-timed crash can do, despite all recovery programs. ("Bad computer, *baaad!*") Image enhancements come later.

Picture processing is a story all to itself. One downside to all this terrific technology is that we get to spend unlimited amounts of time computer-improving the results. How enhanced do you want to get? The standard image additions and corrections to fit the gray scale are best done in the format of the parent program controlling the CCD. Since I print my images out through a business-related imagesetter, I do my processing in 8-bit, PostScript-compatible mode.

A wide variety of inexpensive image processing programs is available, including some "freeware." Programming ability isn't required. Available features permute off into infinity. You can filter data over regions of interest and vary them widely in intensity. There's unsharp masking, thresholding, gamma-curve compensations, and despeckling. You can set up your own noise-control kernels and convolve them six different ways to Sunday — blend the results, or apply 'em arithmetically, logarithmically, or polynomially back to the original. And don't neglect the gradient and edge-detection schemes. Images can be flipped, flopped, rotated, scaled, inverted, sharpened, blurred, embossed, or posterized. You can manually colorize through the combination of individually filtered exposures. And thaaaaat's not all—



The Whirlpool Galaxy, M51.

You say you'd like to see the image's histogram (gray map)? Which way? Conventionally, by selected columns, or three-dimensionally, from any perspective and scale — and here's the printout. What effect does redrawing the map have? Whoa, would ya look at that!

You can merely modify contrast and

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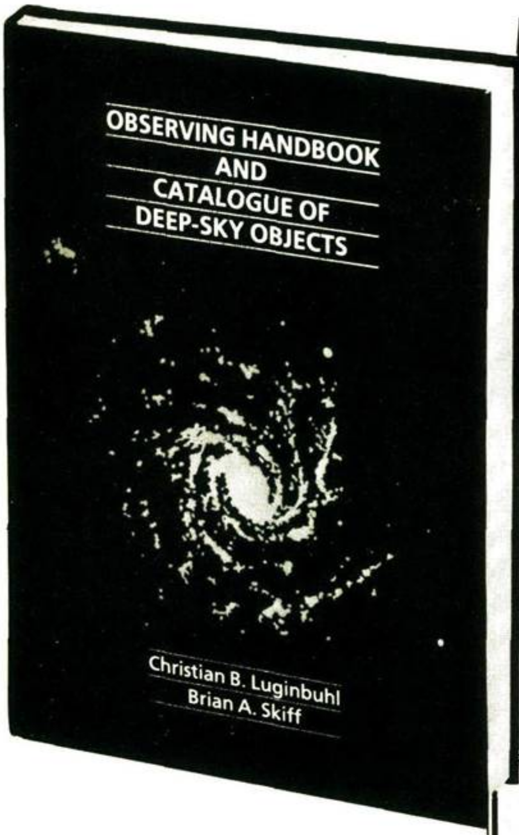

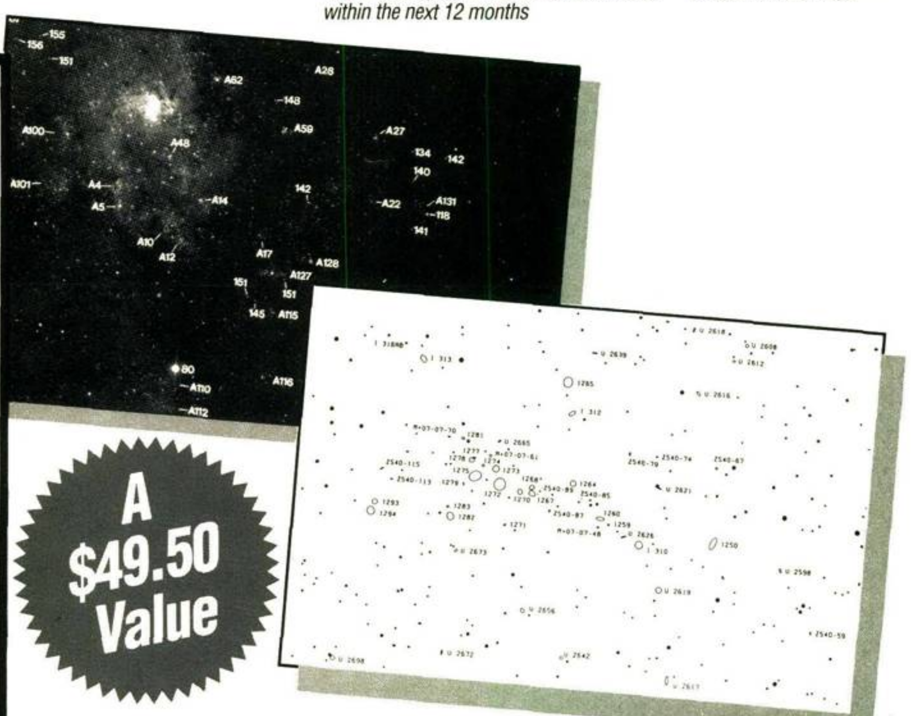

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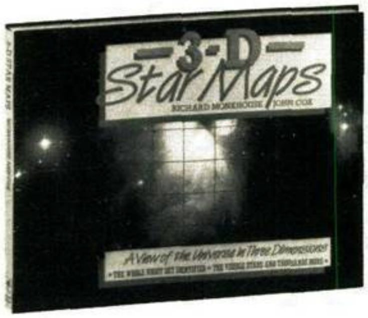
Here is the ultimate reference for amateur astronomers looking for practical guidelines and information on observing deep-sky objects. The *Observing Handbook and Catalogue of Deep-Sky Objects* is the most comprehensive and up-to-date guide to observations and relevant data available.

Over 2,050 galaxies, star clusters, nebulae, and constellations, some detailed for the first time, have been systematically viewed and charted here with dimensions, magnitudes, orientations, and angular distances to help you find and observe them. Plus, the catalogue section of the book contains single-line data entries on almost 3,000 deep-sky objects, including all of those with descriptions or references in the text and all objects plotted on the charts.

You'll find the handbook is simple to use and very thorough. Observations are grouped by constellations in alphabetical order. Actual visual descriptions, in order of three increasing telescope apertures commonly used by amateur astronomers, are provided. Finder charts are included to help with identifying objects in particularly crowded or confusing fields. Six of the brighter clusters of galaxies are also mapped.

Just complete and mail the postage-paid reply card today to get the Observing Handbook for only $1.00 and 3-D Star Maps FREE.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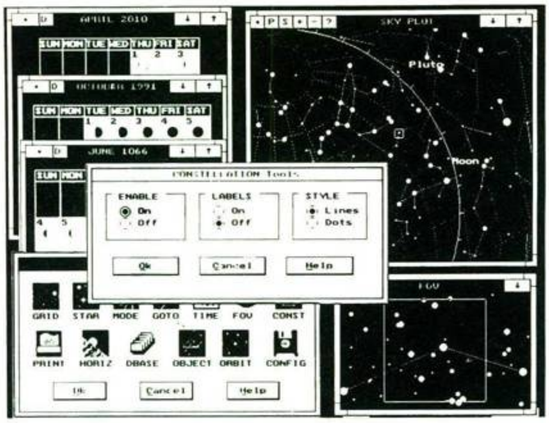

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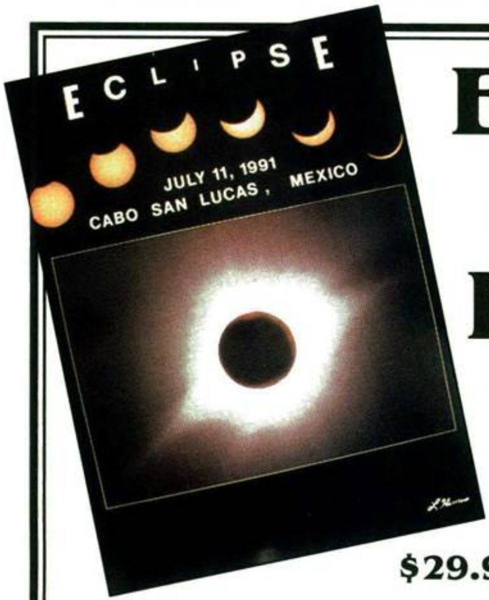

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brightness or change the image one pixel and gray level at a time. There's a whole world of special transformations out there that most of us wouldn't dream of. Yet through all this it helps to remember one guiding principle: If you put garbage into the system, you get processed garbage out, with an enhanced bouquet.

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The Black Eye Galaxy, M64.

Acceptance of electronic amateur astronomy at times appears meteoric. Some veterans of observing recoil because of this. They may see such systems as threatening to supplant the traditional hands-on visual techniques with more detached automated ones. There are trade-offs when CCDs replace eyepieces.

For example, even fervent devotees gasp at the price tag of these components — and rightfully so. (But the equipment is getting cheaper while performance is improving.) Other amateur astronomers, like myself, initially shied away from the apparent complexity of the field. (But we were seduced by its potential.) Lastly, anyone can see that initial CCD imagery pales next to the grandeur of wide-field 90-minute exposures taken at 5,000 feet on fine-grained film.

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PROBLEMS FOR HUBBLE INSTRUMENT

The failure of a low-voltage power supply on the Space Telescope's Goddard High Resolution Spectrograph (GHRS) in late July means that astronomers no longer can get data reliably from that instrument. The setback is particularly disheartening because some of Hubble's best science has come from observations with the GHRS. For example, the spectrograph played a key role in the discovery that numerous clouds of hydrogen populate intergalactic space (see "A Quasar Lights Up the Universe" by Richard Talcott, September 1991).

According to John Brandt, Principal Investigator for the GHRS, the problem is intermittent. Sometimes the instrument gets power and works fine, other times it does not. Unfortunately, no one can predict when the instrument will or won't work. A preliminary analysis of the problem points to a faulty connection in the power supply in one of the instrument's two detectors. Although only one detector is affected directly, data from the second detector can't be returned to Earth unless the first is also functioning.

Engineers are now busy trying to devise a solution to the problem. One possibility would be to transfer all Hubble operations to the spacecraft's backup data bus. Because there's a direct data link between the backup bus and the working GHRS detector, that fix would restore the instrument to nearly 90-percent efficiency. However, the backup data bus was not intended for such a purpose — its role was to replace the primary data bus in the event of a massive failure that affected all the telescope's instruments. Switching to the backup bus would entail putting the telescope into a safemode by shutting it down and then rebooting the computers, a step many astronomers would just as soon avoid.

A second possibility is to have astronauts replace the power supply during the shuttle servicing mission scheduled for late 1993. The astronauts would need to take out 75 screws to remove the power supply and then install a new unit into the GHRS. The big question in this scenario is whether the astronauts will have enough EVA time to make the switch and still accomplish their other tasks.

77 DEAD COWS AND OTHER METEORITE NEWS

A personal moonrock, a thump on the ground, and heaps of old rocks made for several interesting meteorite discoveries in recent months.

Atacama Desert, Chile. This high, dry, and desolate region in South America was the site of an important stony-iron meteorite find by two astronomers from the European Southern Observatory, Holger Pedersen and Harri Lindgren, and a Chilean geologist colleague, Claudio Canut de Bon, of the University of La Serena.

The three painstakingly searched the region where the Vaca Muerta (Dead Cow) meteorite landed, an area about 2 kilometers by 11 km. This meteorite fell about 3,500 years ago and its largest fragments had already been found by 19th-century prospectors. The team's careful search, however, increased the number of found fragments to 77, and brought the total known weight of "Dead Cows" to about 7,500 pounds.

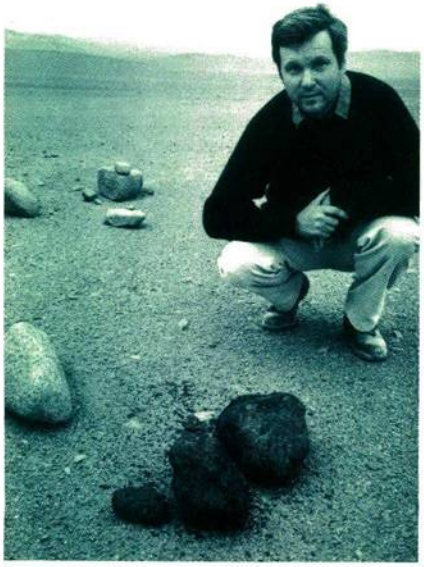
Laboratory study of the Vaca Muerta fall shows that its parent body condensed some 4.5 billion years ago, only shortly after the solar system itself. The meteorites are stony-irons, a rare class of object which results from the collision of one asteroid with another having a metallic core. When the fragments of the collision cooled and solidified, they formed an intricate mixture of minerals that was part metallic and part rocky. This kind of meteorite is rare, with only about 30 other individual falls being known. Scientists are pleased because the Vaca Muerta find has tripled the total known quantity of stony-iron meteorites.

Nullarbor Plain, Australia. Robert Haag is one lucky guy, being the only human who personally owns a chunk of the Moon. Haag's piece is the Calcalong Creek meteorite, named (as all meteorites are) for the location where it was found. A dark, smooth oblong about an inch long, the meteorite weighs only 19 grams (less than an ounce).

Haag is a professional meteorite collector and dealer from Tucson, and the Calcalong Creek find was part of a collection he gathered on a trip to Australia's Nullarbor Plain three years ago. Sorting through roughly 600 pounds of finds from the trip, Haag noted the Calcalong Creek object felt and looked different from the others. Its fused rock crust had tiny gas bubbles (extremely rare in meteorites) and also had a slightly greenish tinge. Carefully shaving off part of the crust to expose the interior, Haag saw a "grey fudge" matrix with tiny white fragments embedded in it.

Turning the rock over to the Lunar and Planetary Laboratory's Dolores

THAT'S A "DEAD COW" IN FRONT of astronomer Harri Lindgren, who found the fragment of the dark Vaca Muerta meteorite fall in Chile's Atacama Desert. ESO photo. Robert Haag's Calcalong Creek meteorite (below) is the only piece of the Moon in private hands. University of Arizona photo by Dolores Hill.



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ASTRONOMICAL INSTRUMENTS

Hill (an expert chemist) and William Boynton (a planetary scientist), Haag had his suspicions confirmed. Chemical analysis showed that the meteorite's composition was unmistakably lunar basalt. In addition, the rock's low titanium content differs from the mare basalts sampled by the Apollo missions, which typically are titanium-rich. The meteorite probably arrived on Earth after being blasted off the Moon by an impact.

Calcalong Creek is the first lunar meteorite to be found outside of Antarctica, which has become a rich source for all kinds of meteorites because its climate and low rates of erosion preserve finds very well. But because the expeditions to discover Antarctic meteorites are funded by governments, all previous lunar meteorites (11 in all) belong to either the U.S. or Japanese governments. Haag is therefore doubly lucky — in the first place, for spotting the object among the others, and second, because the object belongs to him.

Glatton, Cambridgeshire, England. Mr. Arthur Pettifor was planting onions in his backyard when he heard a whistling, whining noise followed by a thump. Looking up, he saw one evergreen in a nearby row of trees moving its branches. He walked over and noted that a low hedge of hawthorn bushes standing right behind the evergreen had some damaged branches. At the foot of the hedge was a small stone. It felt warm to the touch.

The "stone" turned out to be a chondritic meteorite. It measured about 4 inches long and weighed about 1.5 pounds. In landing, the meteorite gouged a "crater" about 4 by 8 inches and a little over an inch deep. The stone is covered with a matte-brown crust, with two corners chipped off. The interior shows a greyish-white matrix with chondrules (spherical mineral grains) about half a millimeter in diameter and flecks of nickel-iron.

The meteorite is the first recovered in England since 1965. Analysis by Robert Hutchison of the British Natural History Museum and Colin Pillinger of the Open University identifies the chondrite as an olivene-hypersthene type. It has 23% iron (with 5% of this being nickel-iron) and olivene and pyroxene are the main stony minerals. Cosmic ray alterations in its minerals indicate that the meteorite broke off from another object less than 3 feet in diameter some 2 million years ago. It then drifted in space by itself until it fell to Earth. — *Jonathan Shanklin*

Amateur News

BEST YEAR YET FOR ASTROFEST

Any list of amateur gatherings is incomplete without AstroFest. Hosted each year by the Chicago Astronomical Society (CAS), it has become the midwest's biggest star party. AstroFest '91 ran from September 6 to 8 and marked the tenth year AstroFest visited Camp Shaw-Waw-Nas-See, a 4-H camp near Kankakee 60 miles southwest of Chicago.

When I arrived on Friday afternoon over 100 cars and associated telescopes were already scattered about the telescope field. By the time registration officially opened at 6 p.m., the telescope field was almost filled.

Friday evening brought clear skies. As twilight faded the Milky Way began to peek out bringing "oohs" and "ahs" from the assembled multitude. After darkness closed in somebody shouted and pointed north at a "star" moving across the Big Dipper. "What is that?" someone asked. "It's Mir, the Soviet space station," replied another observer. Eyes turned to follow the spacecraft as it slid into Earth's shadow. "Not a bad way to begin a night's observing," someone muttered.

As the evening progressed telescopes moved from one object to another. Gasps of appreciation came from those who viewed Saturn through Questars, Newtonians, and apochromats. Murmurs of wonder came from those who saw the North America and Veil nebulae. "Before we came here my wife was happy to look at the Moon and bright planets," one man from Kansas told me. "My wife just saw the Veil and I think she's a convert to deep-sky observing."

One member of the CAS linked his 18-inch NGT to another member's laptop computer and turned the combination into a high-tech object finder. The computer screen showed a map of the sky and crosshairs showed where the scope was pointed. As fast as a person called out a target, the scope's operators slewed the big scope to scoop the object up. The only thing that slowed the process down was the eventual drain of the computer's battery.

"One of the things I like about the weekend is that you can see so many different types of telescopes in action," a voice said out of the darkness. "The scopes tend to cluster — the big Dobsonians are in one area, the apochromats are in another — so you can wander back and forth comparing images, ease of operation, anything that you want."

Affairs like AstroFest are more than telescope displays. They are sources of information to those starting out in the hobby. Standing amid telescopes of all sizes, one amateur was guiding a clutch of novices through the night sky, patiently pointing out stars and constellations. "This is great. Eighty percent of what I've learned about astronomy has come from AstroFest," one of the assembled astro-tourists said. "Wow," exclaimed another, "I didn't know you could see M31 with the naked eye! I'm just learning about this and the people here are very helpful."

Saturday morning brought droves of people into the main hall. Over coffee and chocolate donuts talk turned to amateur gatherings around the country. "They talk about the 'Big Three': Stellafane, Riverside, and the Texas Star Party, but you have to make it the 'Big Four' and add AstroFest to that list,"said Dave Bachtell, a 7-year AstroFest veteran. "This event has a great mix — you have the telescope makers of Stellafane and the observers of TSP."

"Events like this are what amateur astronomy is all about," said CAS vice-president John Jones. "You don't even need a telescope. I saw one guy wandering around last night with a pair of 7x35 binocs." CAS member Carl Buzzard agrees. "AstroFest is for amateurs at all levels, whether they use 7x50 binoculars or a 25-inch Dobsonian. The thing here is to give them all a chance to observe."

Saturday night's sky wasn't as clear as Friday's but that didn't deter anyone from participating in an observing frenzy. But on Sunday morning telescopes began to disappear as quickly as they had arrived. Wandering the field was Alan Birkner, chairman of this year's Fest. "We had a record attendance," he noted, "500 or so from all over the country and even Canada. The sky Friday night was the best we had in years."

The next AstroFest will be from September 18 to 20, 1992. Mark your calendar now. Mine's already circled. — *Mike Porcellino*

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UPDATE ON WHAT'S UP

Galileo — Asteroids and Antennas: In October Galileo performed the first flyby of an asteroid. On October 29, 1991, it flew within 1,000 miles of Gaspra, a potato-shaped asteroid about 6 by 11 miles across. The mission plans called for Galileo to take 155 images of Gaspra, most taken in the hour before closest approach. However, none of these images will be relayed to Earth until just prior to December 1992 when Galileo makes the second of two close passes by Earth to boost its velocity.

The reason for the delay is Galileo's pesky antenna. Its large high-gain antenna has failed to unfurl properly (see "Galileo in Trouble," Space News, August 1991 ASTRONOMY). In June and again in August, engineers at NASA's Jet Propulsion Laboratory tried to unfold the umbrella-like antenna by turning it away from the Sun to get the structure as cold as possible. The hope was that this "cold soak" would contract the central mast by 20 thousandths of an inch, freeing several pins that hold the antenna ribs to the central shaft. (Three ribs are thought to be stuck.) Apparently the pins have become cold-welded to the mast, perhaps because the lubricant that would have prevented this wore off during repeated trips of Galileo to and from Cape Canaveral after the Challenger disaster. However, both attempts failed to get the antenna as cold as is thought necessary to spring the ribs free.

Engineers are still optimistic their efforts will pay off; plans called for another cold soak attempt in December 1991 when Galileo will be farther from the Sun, and therefore colder, than it was earlier this year.

Gamma Ray Observatory — A High-Energy Success: Engineers are calling it one of the healthiest spacecraft they've ever seen in the first four months of its life. As of December 1991, GRO, the second of NASA's Great Observatories, was about halfway through the first phase of its mission, a 15-month survey of the gamma-ray sky. During the summer, GRO was aimed at three unplanned targets: the Sun during the June 8 to 15 period of intense solar flares, a new supernova called 1991T, and Cygnus X-3 during an unexpected radio outburst.

GRO's instruments are seeing about one gamma-ray burst per day, including the shortest bursts ever detected. (See "A Burst of Gamma Rays," October 1991 ASTRONOMY.) An experiment called COMPTEL has also made one of the first images of a gamma-ray burst. Another instrument has discovered gamma rays coming from 3C 279, making this quasar the most distant and luminous gamma-ray source yet seen. However, this same source should have been visible to two previous gamma-ray missions, NASA's Small Astronomy Satellite and the European COS-B. Neither satellite detected 3C 279, indicating that whatever generates the gamma rays in the quasar has turned on since the earlier satellites flew in 1973 to 1982.

GRO scientists are excited about the amount of gamma-ray activity that GRO has detected all over the sky. As project scientist Neil Gehrels put it, "If activity continues at this pace throughout the mission, we will all die of exhaustion — but with smiles on our faces."

Giotto — Gearing Up for Encounter 2: The European spacecraft that passed within 350 miles of the nucleus of Comet Halley in 1986 is being prepared for another comet flyby. In June 1991, the European Space Agency gave the go-ahead for the Giotto Extended Mission culminating with a July 10, 1992 encounter with Comet Grigg-Skjellerup.

Magellan — Going Around One More Time: The Venus orbiter is currently in its second 243-day-long cycle of mapping the surface of Venus. (Cycle one was completed May 8, 1991. See "Venus, Planet of Fire," September 1991 ASTRONOMY.) Magellan is now using its radar mapper to sweep over old ground searching for changes and filling in the gaps left during the first passes, especially in regions around the previously unseen south pole. As of September, Magellan had imaged 90 percent of the volcanic Venusian surface. This second cycle of mapping will end January 15, 1992. Venus should be fully mapped sometime in cycle three that begins January 16.

Ulysses — Approaching Jupiter: The joint U.S./European 5-year mission to study the Sun got a chance to do so last summer when Ulysses passed behind the Sun as seen from Earth. Radio waves sent out by Ulysses traveled through the denser part of the Sun's atmosphere, the corona. At their closest, on August 21, the radio waves passed 1.3 million miles above the Sun's surface, the photosphere. Subtle changes in the radio waves will allow solar astronomers to learn more about the density, turbulence, and composition of the Sun's inner corona, the region where the solar wind is thought to originate.

Ulysses will fly within 235,000 miles of the cloudtops of Jupiter on February 8, 1992. The gravity of Jupiter will then fling Ulysses on a path that will take it below the Sun's south pole in 1994. Ulysses will be within Jupiter's magnetosphere for just over seven days during which time the spacecraft will measure previously unexplored regions of the Jovian magnetosphere. Don't expect images from this Jovian encounter — Ulysses has no camera.

Upper Atmosphere Research Satellite — Going Up to Look Down: The first satellite in NASA's Mission to Planet Earth program is now in space. On September 14, astronauts aboard the shuttle Discovery placed the Upper Atmosphere Research Satellite into a 320-mile high circular orbit around Earth. From their vantage point, nine instruments on board UARS will look down upon the thin veil of gases that surrounds our planet. A 10th instrument will measure fluctuations in the output of the Sun. UARS is expected to provide the first complete picture of the chemistry, winds, and energy balance of the layers of the atmosphere 9 to 30 miles above the surface, including how two important forces change the atmosphere: manmade chemicals from below and solar energy from above. The $633 million satellite is designed to function for a minimum of 3 years, and has enough fuel on board to allow it to continue watching Earth for a decade.

Voyager — Still Useful After All These Years: The two famous planetary probes have been turned into stellar observatories. The cameras have been turned off but one instrument on each of the Voyagers' scan platforms continues to function. Astronomers are using this instrument, the ultraviolet spectrometer, to take spectra of hot stars such as blue giants and white dwarfs. Stellar astronomers from around the world can apply for observing time on the Voyagers just as they would on any ground-based or Earth-orbiting telescope — except that these observatories are at the edge of the solar system! ☐

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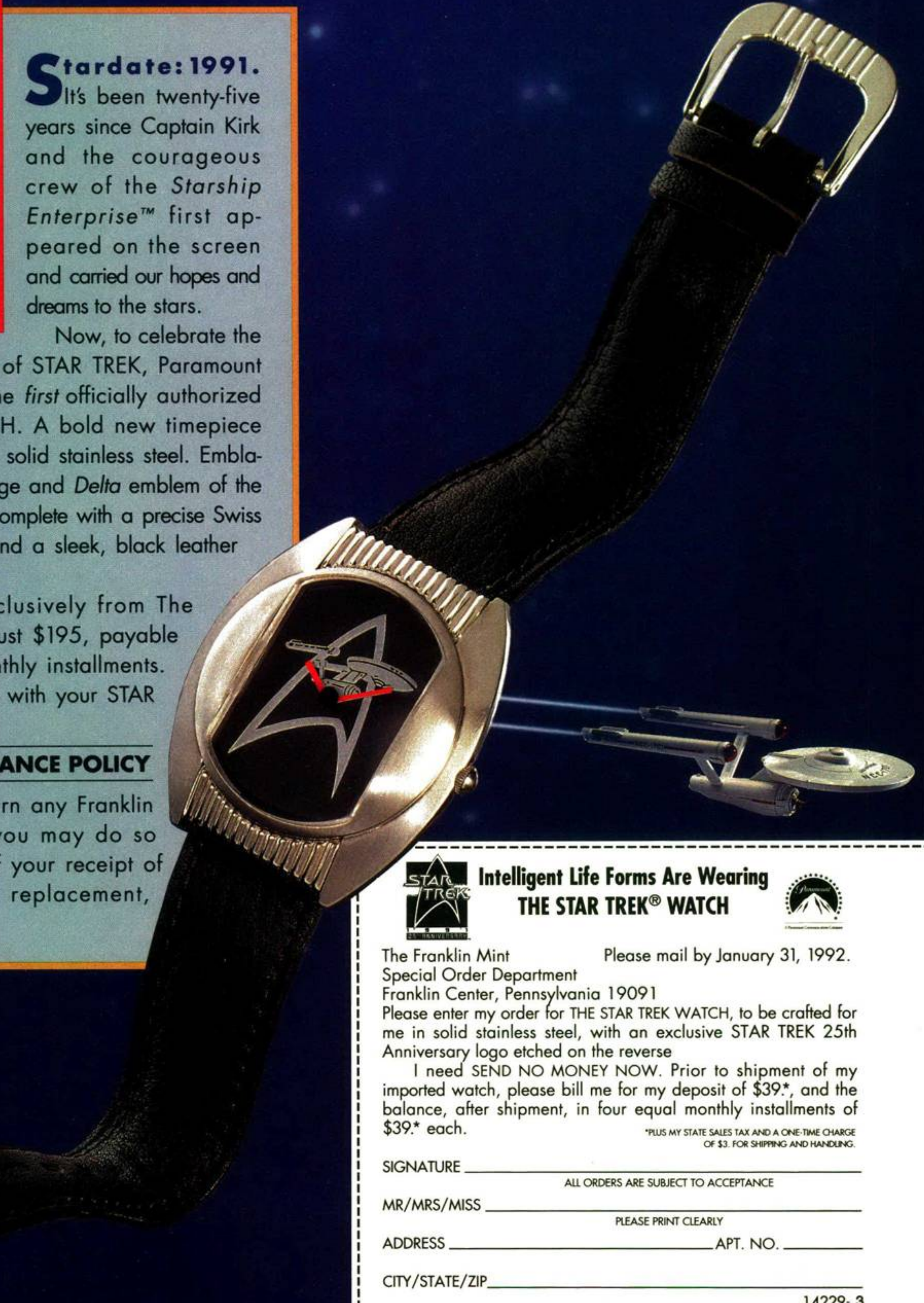

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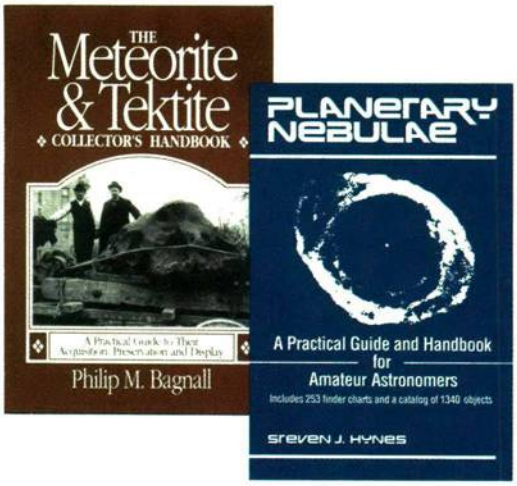
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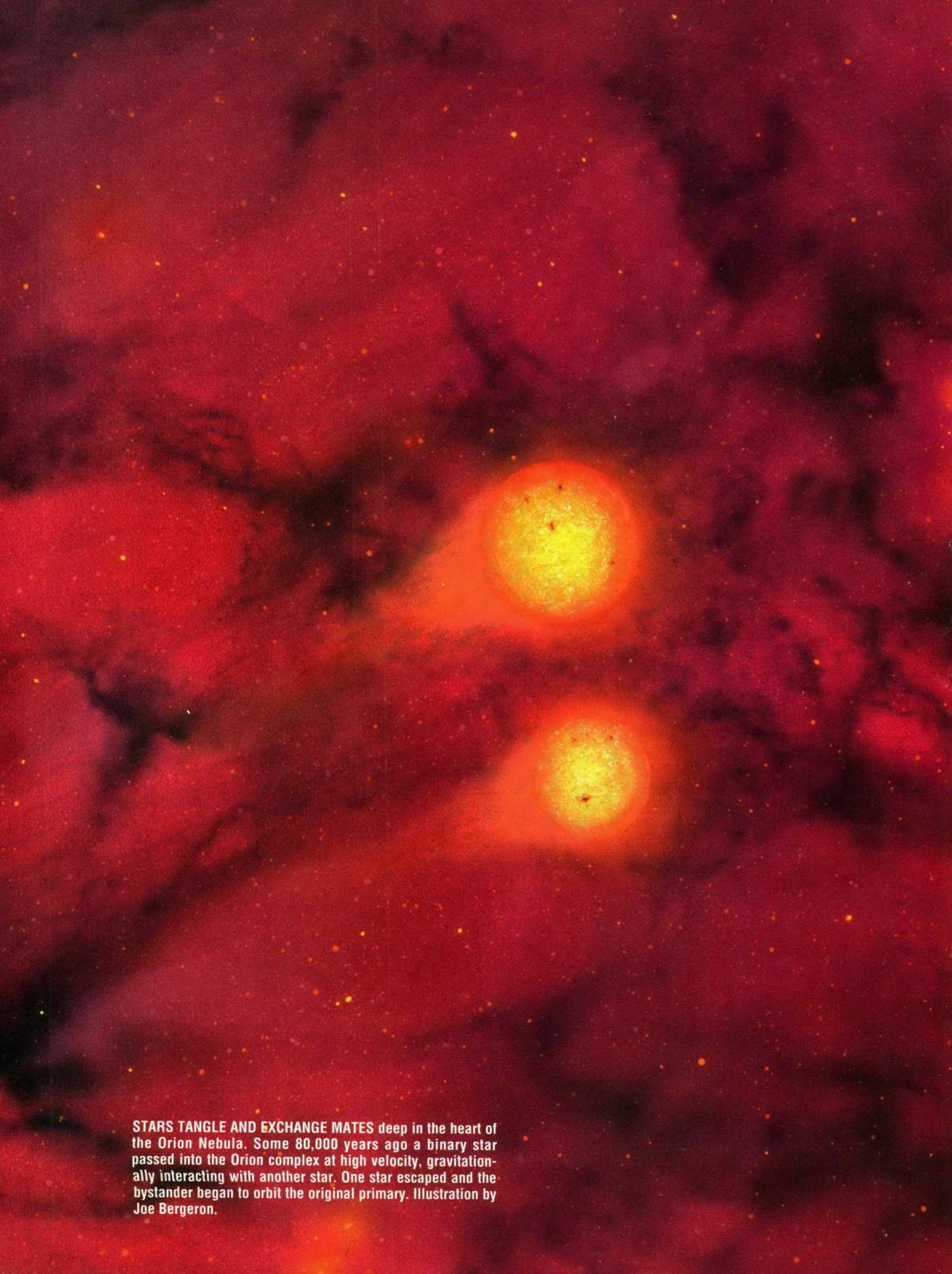
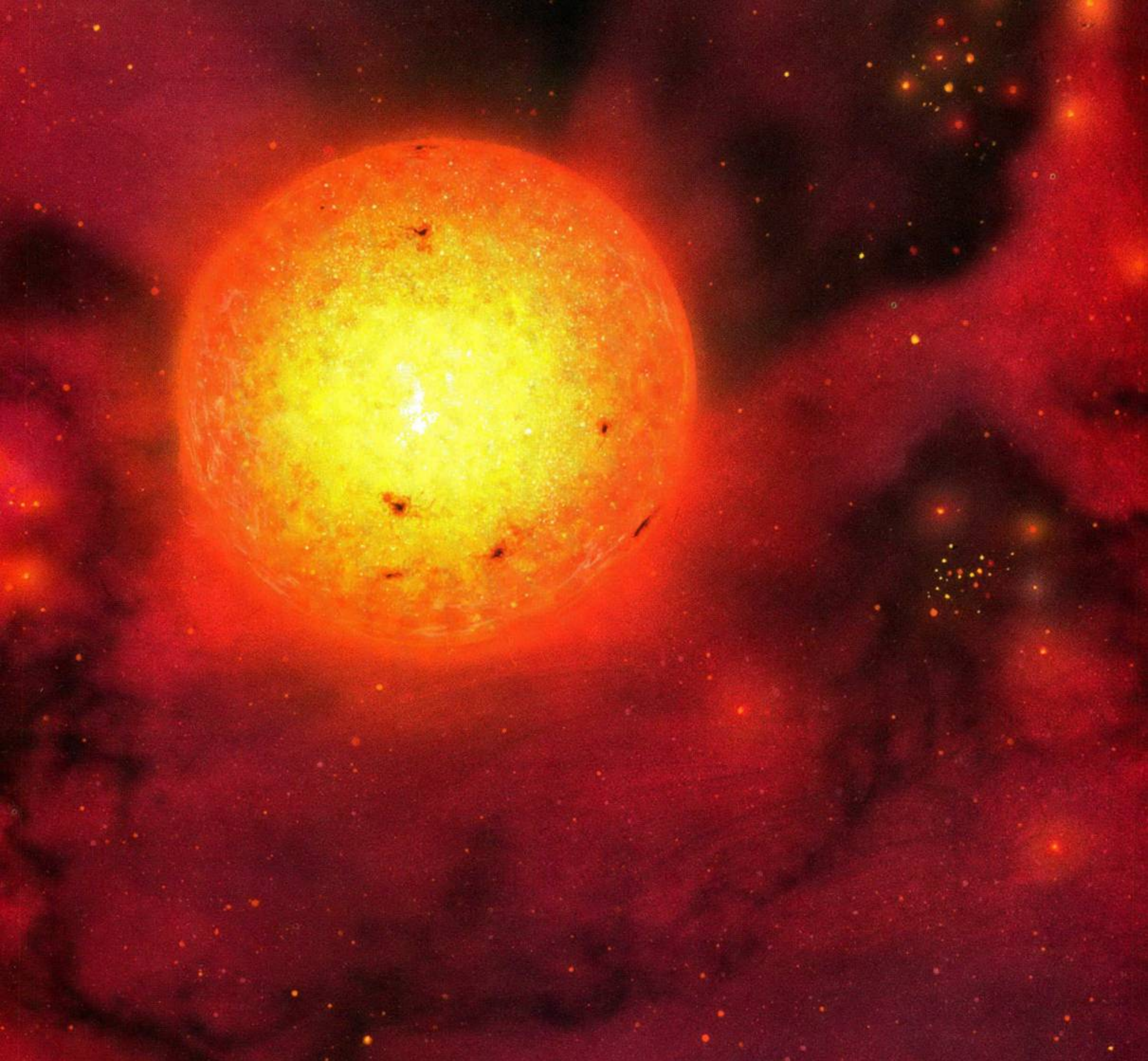


STARS TANGLE AND EXCHANGE MATES deep in the heart of the Orion Nebula. Some 80,000 years ago a binary star passed into the Orion complex at high velocity, gravitationally interacting with another star. One star escaped and the bystander began to orbit the original primary. Illustration by Joe Bergeron.



ASTROPHYSICAL RESEARCH

Encounter in ORION

A young double star fleeing the Orion Nebula at high speed provides insight into how binary stars form — and how they escape their birthplaces.

by Ken Croswell

Stars, like people, usually have mates. Though our lonely Sun is single, most stars in the Galaxy — such as Sirius and Procyon — have partners to keep them company through the night.

People, of course, go through an elaborate process during which they meet and court their mate. How double stars form, however, remains unknown. Some stars may be born double, while others, like people, may start their lives single and encounter their lifelong companion later.

"There's no answer yet to this question," says Robert Mathieu of the University of Wisconsin at Madison, who studies binary stars shortly after they are born. "It's the hot subject right now in star formation theory."

To learn how binaries form, Mathieu must catch the stars while they are still very young — while the stars are in the pre-main-sequence phase. During the pre-main-sequence phase, the star gradually contracts, generating light by converting gravitational energy into heat.

As the pre-main-sequence star gets smaller, its core gets hotter and hotter, until the star ignites its hydrogen and joins the main sequence. On the main sequence, a star generates energy by fusing hydrogen into helium at its core. Ninety percent of all stars, including the Sun, are main-sequence stars.

Pre-main-sequence stars, however, are rare, because a star spends only a brief amount of time in this stage of evolution. Therefore, binaries containing two pre-main-sequence stars hold vital clues to how binaries form.

In some cases, stars might be just like people, mating long after they are born.

Recently, one such pre-main-sequence binary in the Orion Nebula has attracted a lot of attention: Parenago 1540, first catalogued by the Russian astronomer P. P. Parenago in 1954. Parenago 1540 is a remarkable double star which implies that, at least in some cases, stars are like people in that they form unions well after their birth.

When Mathieu and his colleague Laurence Marschall of Gettysburg College measured the age of Parenago 1540, they found that one star in the binary appears to be twice as old as the other, suggesting that the two did not form together. Furthermore, Parenago 1540 is escaping the Orion Nebula at high speed. This indicates that the binary has suffered an encounter with another star that has tossed Parenago 1540 out of the star-forming region of the Orion Nebula for good. This may explain how the stars joined together.

"If we can decipher Parenago 1540," says Mathieu, "we may gain unique insight not only into the formation of binaries but also into the dynamics of young star clusters."

Young Couples

Like all binaries, pre-main-sequence binaries come in two main types, visual and spectroscopic. Astronomers have known about visual pre-main-sequence binaries since the 1940s. In these systems, astronomers can see the two different stars.

Unfortunately, the nearest pre-main-sequence stars are 500 light-years away. Hence, to appear as a visual binary the two stars must be separated by huge gaps of space. Because of this large separation, the stars move about each other slowly, taking thousands of years to complete an orbit. This makes it impossible for astronomers to determine the stars' orbits and masses.

During the last ten years, however, astronomers have discovered a new type of pre-main-sequence binary, the so-called double-lined spectroscopic binary, which allows astronomers to derive orbits and masses for the two stars.

Two stars in a pre-main-sequence double-lined spectroscopic binary lie so close together that they typically revolve around each other every few days or weeks. Because the stars lie close together, astronomers cannot see the two stars individually.

Instead, spectra reveal two different sets of spectral lines, one set for each star. As the stars orbit each other, one star approaches us as the other recedes from us. This orbital motion produces periodic redshifts and blueshifts of the stars' spectra that reveal the binary's orbital period.

The spectra also measure how much more mass one star has than the other, because the lighter star orbits faster than the heavier one. Mass is crucial, because mass dictates a star's rate of evolution and is therefore a prerequisite to measuring the star's age. The more mass a star has, the faster it evolves. Knowing both a star's mass and its state of evolution allows us to deduce its age. If two stars in a binary have equal ages, they probably formed together. If the two stars have different ages, then more interesting possibilities arise — as may be the case for Parenago 1540.

A Date with Parenago 1540

Pre-main-sequence double-lined spectroscopic binaries therefore hold the key to determining the ages of both stars in a young binary. Astronomers found the first such system, V826 Tauri, in 1982. Since then, only a few more have been discovered. One of the most tantalizing is Parenago 1540.

Mathieu and Marschall first studied Parenago 1540 during the mid-1980s, as they were observing stars in the Trapezium star cluster. The Trapezium cluster lies at the center of the Orion Nebula and contains the bright multiple star Theta Orionis. The Trapezium gets its name because the four brightest stars of the Theta Orionis system make the shape of, you guessed it, a

PARENAGO 1540, visible in amateur telescopes, can be seen in this photograph as a faint star near the outer edge of the Orion Nebula. Photograph by Mike Sisk.

trapezium. But the cluster contains hundreds of other young stars as well. Parenago 1540 is one of them, shining at magnitude 11.33 and lying just 10 arcminutes west of Theta Orionis. Like its mates, Parenago 1540 is 1,500 light-years from the Sun.

Mathieu and Marschall observed Parenago 1540 as part of a project they conducted to measure the velocities of the Trapezium cluster's many stars. To do so, they acquired spectra that revealed the redshifts or blueshifts of the stars in the cluster.

"Parenago 1540 was double-lined," says Mathieu, "so right away it intrigued us. It was only the third pre-main-sequence double-lined spectroscopic binary found, so its very existence was an interesting thing in itself." From the periodic shift of the spectral lines, Mathieu and Marschall determined that the two stars orbit each other every 33.7 days, with the heavier star 1.3 times more massive than the other.

But the story didn't end there. "We went through an analysis and found that when we tried to place both components of the binary on the H-R diagram to get masses and ages — by using standard techniques for weighing and dating pre-main-sequence stars — the two stars did not appear to be the same age."

How can one measure a star's age? It's never easy. We know the age of the Sun — 4.6 billion years — only because we can date rocks on the Earth and Moon. For many other stars, however, determining age is impossible. The H-R diagram, a plot of luminosity versus color, helps, especially for pre-main-sequence stars. Bright stars lie near the top of the H-R diagram, dim stars toward the bottom; hot blue stars to the left, cool red stars to the right.

Parenago 1540 is going on a honeymoon — a honeymoon that may reveal how the two stars first dated.

On the H-R diagram, main-sequence stars form a diagonal line from the upper left (bright and blue) to the lower right (faint and red). Pre-main-sequence stars are bright and cool, so on the H-R diagram they lie above and to the right of the main sequence. As a pre-main-sequence star contracts, it moves toward the main sequence.

In principle, stellar evolution theory can show how a pre-main-sequence star with a given mass changes its position on the H-R diagram as the star ages. Therefore, by measuring the luminosity and temperature of a pre-main-sequence star and thereby the star's position on the H-R diagram, one can establish the star's mass and age.

In the case of Parenago 1540, Mathieu and Marschall estimated that the primary has a mass around 2.25 Suns, whereas the secondary has a mass of 1.7 Suns. At present, these stars are cool orange K-type stars. But when they reach the main sequence, both will be white A-type stars, brighter and hotter than the Sun. In fact, Parenago 1540 A will someday resemble Sirius (spectral type A1) and Parenago 1540 B will look like Altair (spectral type A7).

Of course, Parenago 1540 has not yet reached the main sequence. This gives astronomers the chance to date the two components. Two stars of the same mass and same age should also have the same luminosity and temperature — that is, they should have the same position on the H-R diagram. Parenago 1540 A and B have fairly similar luminosities. This implies that the two stars — if of equal age — should also have similar masses. But they don't.

"That's the surprise," says Mathieu. "The mass ratio for the system is relatively large, considering that both stars seem to be of roughly comparable luminosity." This result may suggest that the stars are different ages. In 1988, Mathieu and Marschall reported that their best estimates gave Parenago 1540 A an age of one million years and Parenago 1540 B an age of only half a million years.

The Problems of Dating a Younger Star

It's tricky to measure the ages of young stars, however. Taken at face value, the different ages of Parenago 1540 A and B imply that the two stars did not form together. But Mathieu is the first to warn against overinterpreting the result.

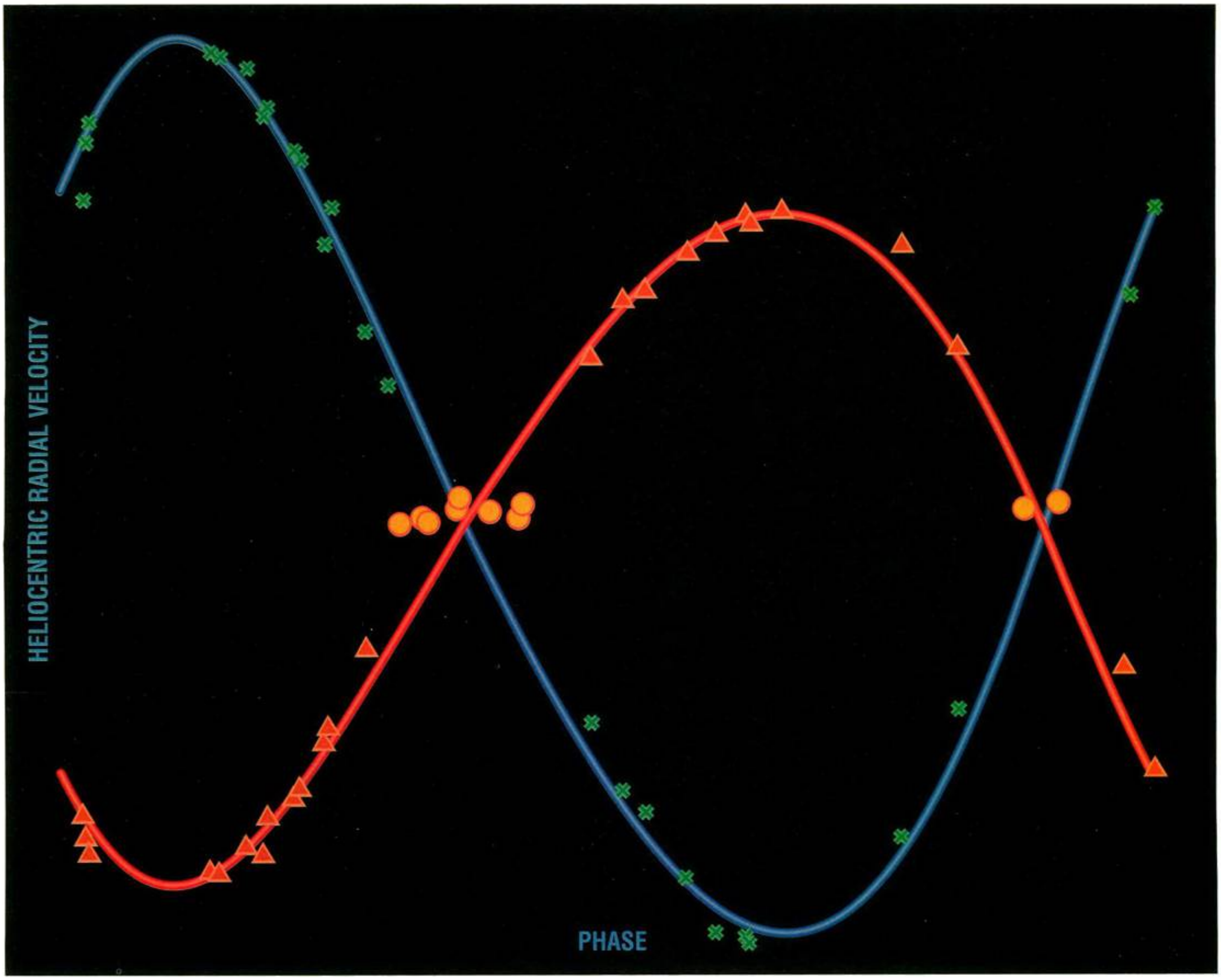
"It's a very, very difficult analysis," he says. "There are a lot of steps from the data to the result, all of which have ambiguity, as most scientific analysis does.

"I have been very careful when I refer to Parenago 1540," says Mathieu. "An attempt to reduce it to its essence can make the result appear far stronger than it is. You go through the error analysis, discuss all the qualifications, and then it often boils down to somebody saying these stars didn't form at the same time. But it's not that definitive."

Determining a pre-main-sequence star's correct placement on the H-R diagram is the first problem. In order to do that, one must know the star's luminosity and temperature. But the luminosity can be wrong because obscuring disks often surround pre-main-sequence stars. These disks, where planets possibly form, block some of the stars' light, which is then re-radiated in the infrared. Errors may also appear in the derivation of a star's temperature from its spectral type. Furthermore, dust lying between us and Parenago 1540 can affect the observations. Even worse, more dust may lie in front of one star than the other.

Problems also exist with the theory. Exactly how does a pre-main-sequence star contract toward the main sequence? No one has ever seen a star do it. So astronomers must rely on theoretical calculations of how pre-main-sequence stars evolve. The question is complicated by the fact that if disks surround the stars, those disks could affect the stars' evolution. Furthermore, says Mathieu, "The presumption that single-star pre-main-sequence evolutionary tracks are relevant for two stars that may have formed in very close proximity is not at all clear." Indeed, one star in a binary may disturb the other's evolution, rendering impossible an attempt to determine ages from standard theory that has been developed for single stars.

Despite the possible errors, Mathieu and Marschall believe that Parenago 1540 may contain two stars of differing ages. And another pre-main-se-



A RADIAL VELOCITY CURVE of the Parenago 1540 system shows the relative motions of the primary (marked by triangles) and the secondary (marked by circles). The more massive primary orbits more slowly than the secondary, which has several important implications.

quence spectroscopic binary — V4046 Sagittarii — has the same characteristic. V4046 Sagittarii consists of two stars with equal masses of 0.7 Suns. If the two stars are the same age, they should also have the same luminosity and temperature. Yet one star is twice as bright as the other.

"A student of mine, Chi-Wai Lee, is presently doing a dissertation on several pre-main-sequence binaries," says Mathieu. "He's developing more sophisticated analysis techniques than Larry and I used. I'm hoping that the sum of all these binaries together will provide a more definitive statement of whether or not Parenago 1540 is unusual and whether or not our result is to be believed."

In one respect, though, Parenago 1540 is definitely unusual, in a way that suggests the stars do not have equal ages: Parenago 1540 is shooting straight out of the Trapezium.

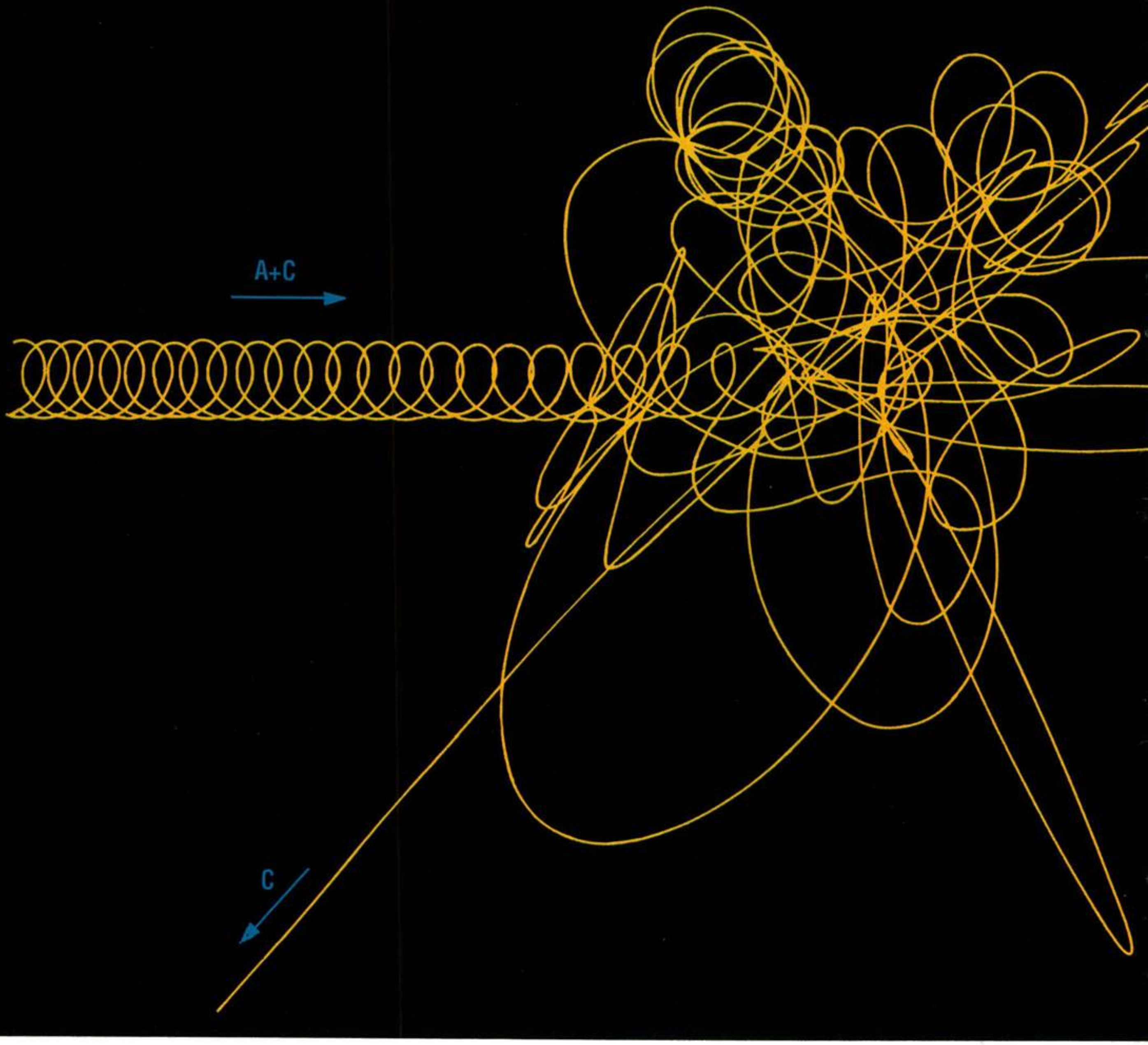
Parenago 1540's Honeymoon

Like many newlyweds, Parenago 1540 is going on a honeymoon — a honeymoon that may reveal how the two stars first dated and mated. The star system is fleeing its place of marital union at high speed, never to return. Astronomers know this because Parenago 1540's proper motion points due west, directly away from the Trapezium. By tracing back its velocity, Mathieu and Marschall estimate that the star got ejected from the cluster only 80,000 years ago.

"This may close the picture," says Mathieu. "It's conceivable that the reason the two stars are different ages — if they are — is that they did not in fact form together. Rather, the pairing may have been produced during a dynamical interaction that ejected the binary from the cluster."

The most likely scenario for Parenago 1540's ejection works like this. A single star in the Trapezium cluster encounters a binary star in the Trapezium. The single star splits the binary by kicking out one of the binary's two stars and mates with the remaining star — it's a homewrecker! The new binary then converts some of the original binary's orbital energy into kinetic energy, and the new binary flies away from the cluster at high speed.

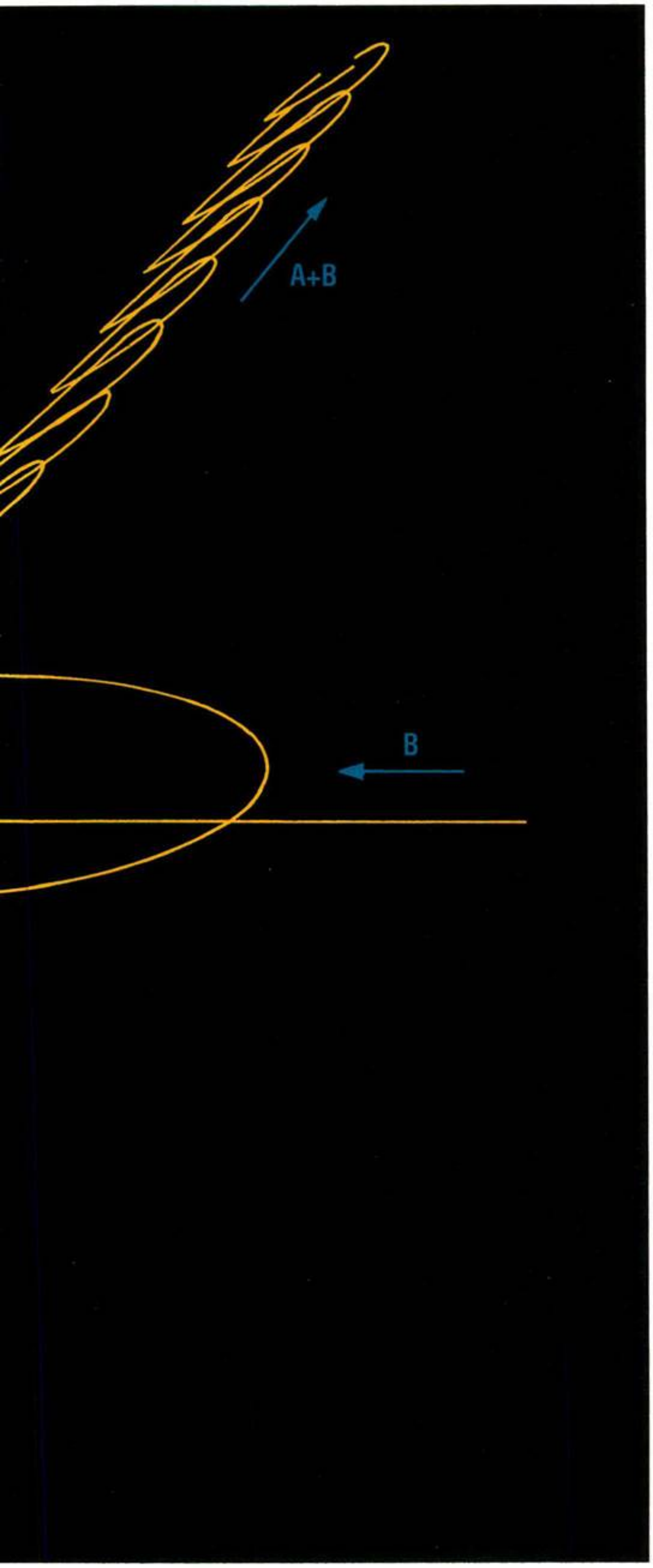
Birth of a Double Star



"Stellar dynamicists have been predicting for a long time that such encounters should occur in star clusters," says Mathieu. "To actually see evidence for it is very exciting."

Other scenarios for Parenago 1540's ejection also exist. Two isolated stars without proto-planetary disks cannot come together and form a binary, for the stars fly past each other and cannot capture each other. If the stars have disks, though, the disks can dissipate the stars' energy of motion so that the two stars might be able to become a binary.

Another possibility — which works even if the stars have no disks — involves three separate stars that come together simultaneously, producing a bi-



A GRAVITATIONAL DANCE occurred between Parenago 1540 and a third star. This simulation shows the original binary entering at high speed from the left and encountering the third star (at right), as well as a new binary consisting of stars 1 and 3 exiting at upper right.

nary and a single star. In this case, the single star carries away the extra energy and allows the other two to mate.

In all these scenarios, Parenago 1540 A and B form separately from each other and so should not have equal ages. If Parenago 1540 A and B actually have the same age, an encounter could still cause their flight from the cluster: a binary can meet a single star, remain intact, and still receive a shot of energy that sends the binary out of the cluster.

Intriguing though these scenarios are, one problem exists, for Parenago 1540 has a low eccentricity — its orbit is more circular rather than elliptical. "If an exchange of stars has occurred, you expect the binary that is ejected to have a very eccentric orbit," says Mathieu. But Parenago 1540's orbital eccentricity is only 0.12, close to circular.

"The trouble is, you're dealing with a case of one. Although the probability of getting an eccentricity of 0.12 is small, it's not zero — in fact, it's not even negligible. So it doesn't worry me, but obviously I'd feel better if the eccentricity were 0.8!" Furthermore, if the two stars of Parenago 1540 had dust disks around them prior to their mating, these disks could have produced a more circular orbit.

Longtime Companion

Even though its past is not yet clear, Parenago 1540 has a secure future. Both stars in the binary will contract and heat up, changing from orange to yellow to white. A few million years from now, the more massive star will ignite the hydrogen at its core and join the main sequence. Then, a few million years later, the less massive star will follow suit. What was once a pre-main-sequence binary will become a binary consisting of two full-fledged A-type main-sequence stars.

And despite their perhaps stormy past, the two stars will stay together. Both are escaping the dense Trapezium cluster at high speed; from now on, they will orbit the Galaxy as a pair. Chances are, they will never again come close enough to another star to be torn apart.

Meanwhile, Parenago 1540 might make us wonder about our own solitary Sun. If Parenago 1540 formed as a result of an exchange between a binary and a single star, creating a new binary and a new single star, the star that is now single was once part of a binary.

Might the same thing have happened to our Sun? Four and a half billion years ago, as it was being born in a star cluster, did our Sun have a faithful companion that circled it — a companion that was torn away by a bigger star? And if so, where might that lost star now be? On the other side of the Galaxy?

We may never know. But Parenago 1540 should at least raise the possibility that, during its youth, even our single Sun may have felt the attraction of a close stellar companion. ☐

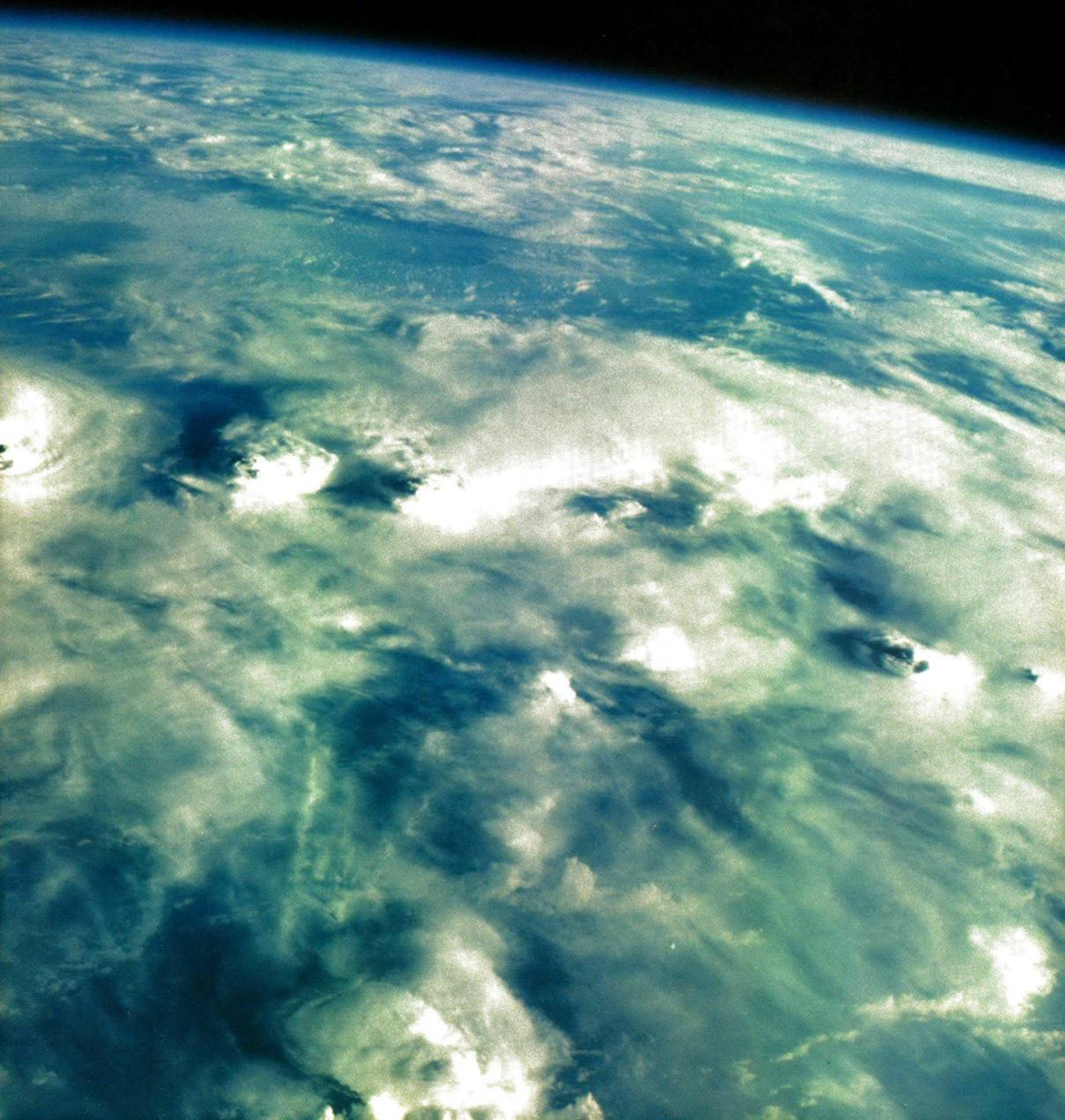
Ken Croswell is an astronomer in Berkeley, California, and a frequent contributor to ASTRONOMY. He also writes for New Scientist, Science, *and* Star Date. *Ken's last ASTRONOMY article was "Will the Lion Roar Again?" in the November 1991 issue.*

EARTH'S ATMOSPHERE:
TERRESTRIAL OR EXTRATERRESTRIAL?

A PUNCH BOWL OF INGREDIENTS, the atmosphere of Earth (like those of Mars and Venus) was born amidst violent impacts when the planet was accreting. Ever since, it has been subject to constant modification. NASA photo.

New studies indicate that the atmosphere of Earth — like that of the other terrestrial planets — may have been born with the planet itself and not simply outgassed in volcanic eruptions. And it may have been a choking hot steambath denser than Venus' atmosphere today.

by Leigh Broadhurst



Where did our planet's atmosphere come from? This seemingly simple question is surprisingly hard to answer. And as planetary scientists work toward a solution, they are finding that the origin of Earth's atmosphere is inseparably linked to the origins of all the terrestrial planets.

Around 4.6 billion years ago, our solar system began when a cloud of dense interstellar gas and dust coalesced under its own gravity in a gigantic swirl. About 98 percent of this cloud, which scientists call the solar nebula, was composed of hydrogen and helium. Most of the nebula collapsed to form the Sun, but a small amount spun out in a broad disk surrounding the newborn star.

Dust grains slowly settled to the midplane of the disk and clumped to form larger particles. These clustered into planetesimals, the building blocks of planets. Made of ice, rock, and metal, planetesimals ranged from under a meter to perhaps 100 kilometers in diameter. In the whirling nebular disk, planetesimals collided with one another and gradually built up the solid parts of the planets. Far from the Sun, the cores of Jupiter, Saturn, Uranus, and Neptune grew so massive that their gravity could attract and hold large volumes of solar nebula gas. Today the surfaces of these planets lie buried thousands of kilometers deep. We can see only the tops of their massive atmospheres, which are mostly hydrogen and helium.

The terrestrial planets — Mercury, Venus, Earth, and Mars — are dramatically different, being composed almost entirely of rock. Close to the Sun's warmth, they are not massive enough to retain for long atmospheres of lightweight gases such as hydrogen and helium. (In fact, Mercury is too small and too hot to hold onto any permanent atmosphere.) Instead of captured solar nebula gases, Venus, Earth, and Mars are today wrapped in relatively thin atmospheres rich in heavier gases such as nitrogen, oxygen, and carbon dioxide. Scientists think these atmospheres are not original, as is Jupiter's, but are secondary in nature. So the question arises where did they come from?

Planetary scientists have long known that volcanic activity is an important way for gases produced inside a planet to reach the surface. Given enough time this process, called volcanic degassing, could create an atmosphere on a terrestrial planet. But recent laboratory research has cast doubt on whether volcanic activity by itself could create the present atmospheres belonging to the terrestrial planets.

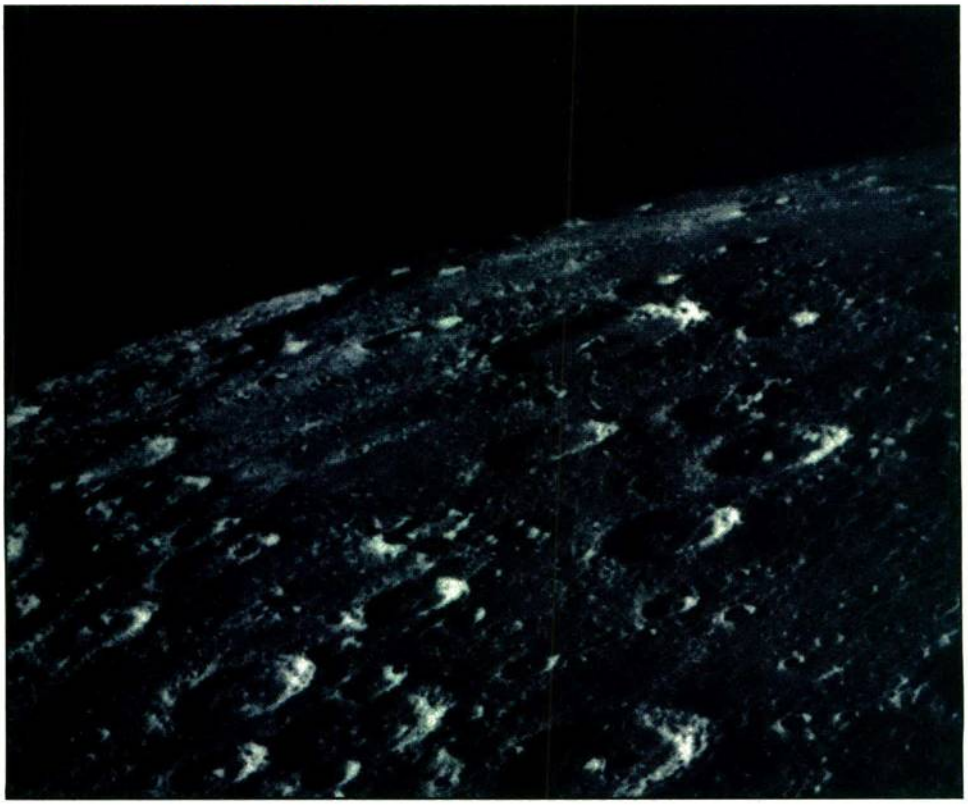
To understand this recent change in thinking, let's first examine how a terrestrial planet "works" volcanically. We'll pick Earth as the example because it's our home and its structure is pretty well understood. At the center of Earth lies a hot metallic core surrounded by a thick rocky mantle. The mantle is capped by a thin skin, the crust. Overlying the crust and thinning into space are the hydrosphere and atmosphere. (The hydrosphere includes oceans, fresh water, glaciers, and ice caps. Scientists often lump it with the atmosphere because both contain the same basic group of chemical elements.)

Among the terrestrial planets, Earth stands out for its high degree of volcanic activity and unusually mobile crust, although many of its features can be found in modified form on Mars and Venus as well. Earth's surface is covered with a small number of moving rocky plates made from two kinds of crust. The crust in the ocean basins is thin (10 kilometers thick on average) and made of a dense rock called basalt, rich in iron, calcium, and magnesium. The crust of the continents is thick (30 to 80 km) but less dense; it is made of granitic rocks rich in silica, sodium, and potassium.

Most continental crust formed in

Diameter: 4,878 kilometers
Surface gravity (Earth = 1.0): 0.28
Average temperature: 440 kelvins
Surface pressure (Earth = 1.0 bar): virtually zero
Main atmospheric constituents: helium, sodium, and oxygen from the solar wind and the planet's surface and interior
Brief history of atmosphere: runaway greenhouse, then all elements lost to space because of solar heating

MERCURY



the first 2.5 billion years of Earth's history, and little or nothing has been added since. Oceanic crust, however, is very different. It is created at mid-ocean ridges and destroyed or recycled at subduction zones, where it slides beneath the continental crust back into the upper mantle from which it came. The force of this encounter often buckles the continental margin into a belt of folded and faulted rock and gas-venting volcanos that roughly parallels the shoreline: for example, the Peru-Chile trench and the Andes Mountains along the western edge of South America.

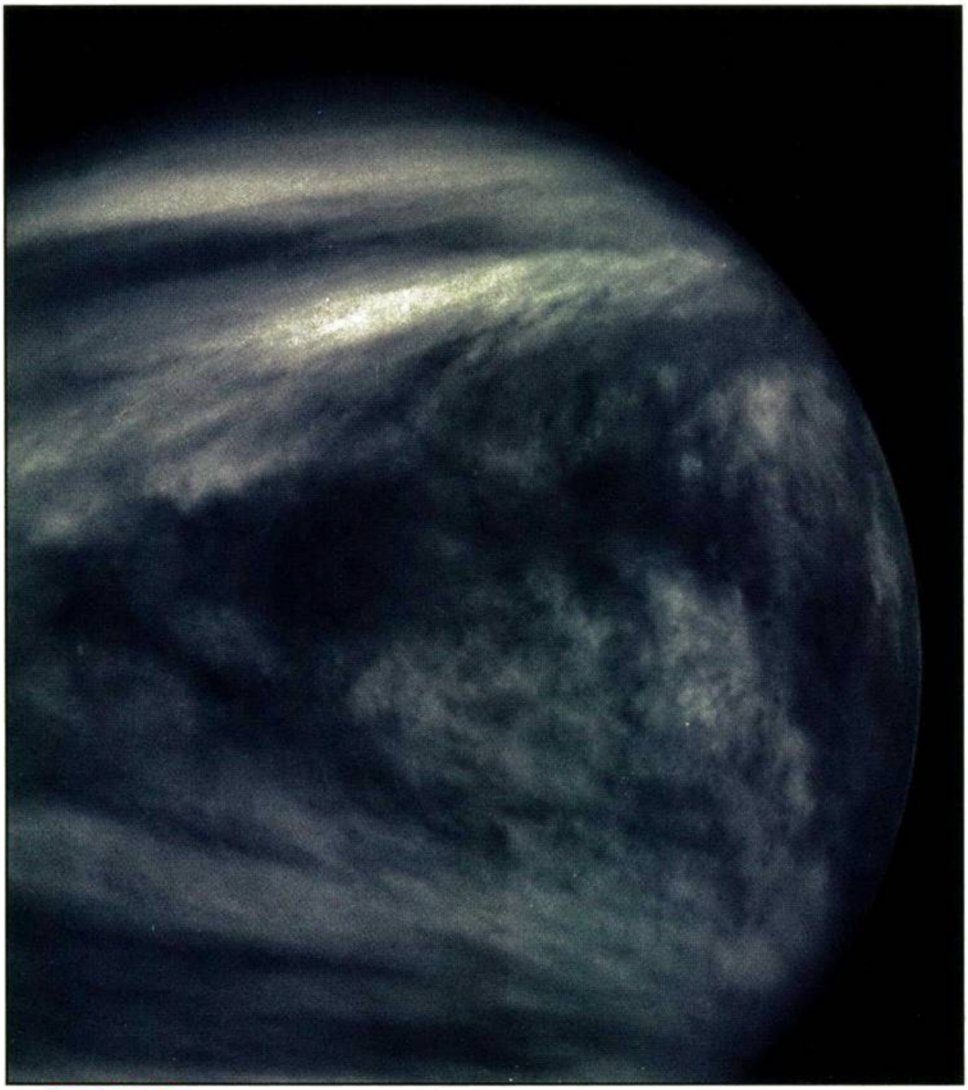
Although volcanos such as Mt. Pinatubo capture the headlines, year after year far more gas is released quietly at the mid-ocean ridges where new oceanic crust is born. Some gas is also added to our atmosphere by volcanos in the centers of plates, such as Hawaii, where hot spots in the underlying mantle punch up through the oceanic crust.

Other planets show features like these in part. Images from the Viking Orbiter show ancient volcanos on Mars similar to the hot-spot type, although there is no evidence for past or current global tectonics. Magellan radar images show that volcanic activity on Venus was extensive in the past, and there is some evidence that limited eruptions are occurring today (see "Does Venus Have Active Volcanos?" July 1990). However, we have yet to see evidence for Venusian global plate tectonics.

Gases inside Earth begin their journey out to the atmosphere when magma (liquid rock) is born by the melting of a small part of Earth's mantle. Magma can absorb a variety of trace ions — discarded chemical species — which do not fit easily into the crystal lattices of the unmelted rock minerals and thus are readily picked up. In addition to trace ions, gases and water are also dissolved in the magma at the high pressures within the mantle. When the molten rock reaches the low-pressure surface, these volatiles bubble out or explode from the magma and add to the atmosphere.

Many scientists have considered the mechanisms whereby various gases are carried in this vertical conveyor belt from the mantle to the atmosphere. They have sought answers to questions such as how much gas can be dissolved in magmas and in the mantle rocks? How easy is it to transport volatiles to a planet's surface? And how do volatiles evolve on the way? The answers they have found lately tend to upset the tidy picture of volcanic magma conveniently dredging up gases from the mantle and dumping them into the atmosphere.

When studying atmospheric gases, however, scientists encounter a problem in that most gases are chemically reactive. This blurs their past and makes their evolution hard to discover. So scientists have focused on the noble gases, the atoms helium, neon, argon, krypton, and xenon. Noble gases are chemically inert — they do not react with other chemical species. In effect, they simply hitchhike on the ascending magma and go along for the ride. This chemical passivity means that if we compare how much argon, say, is in the present atmosphere of a planet with how much should be contained in its rocks, we can estimate how much activity has gone

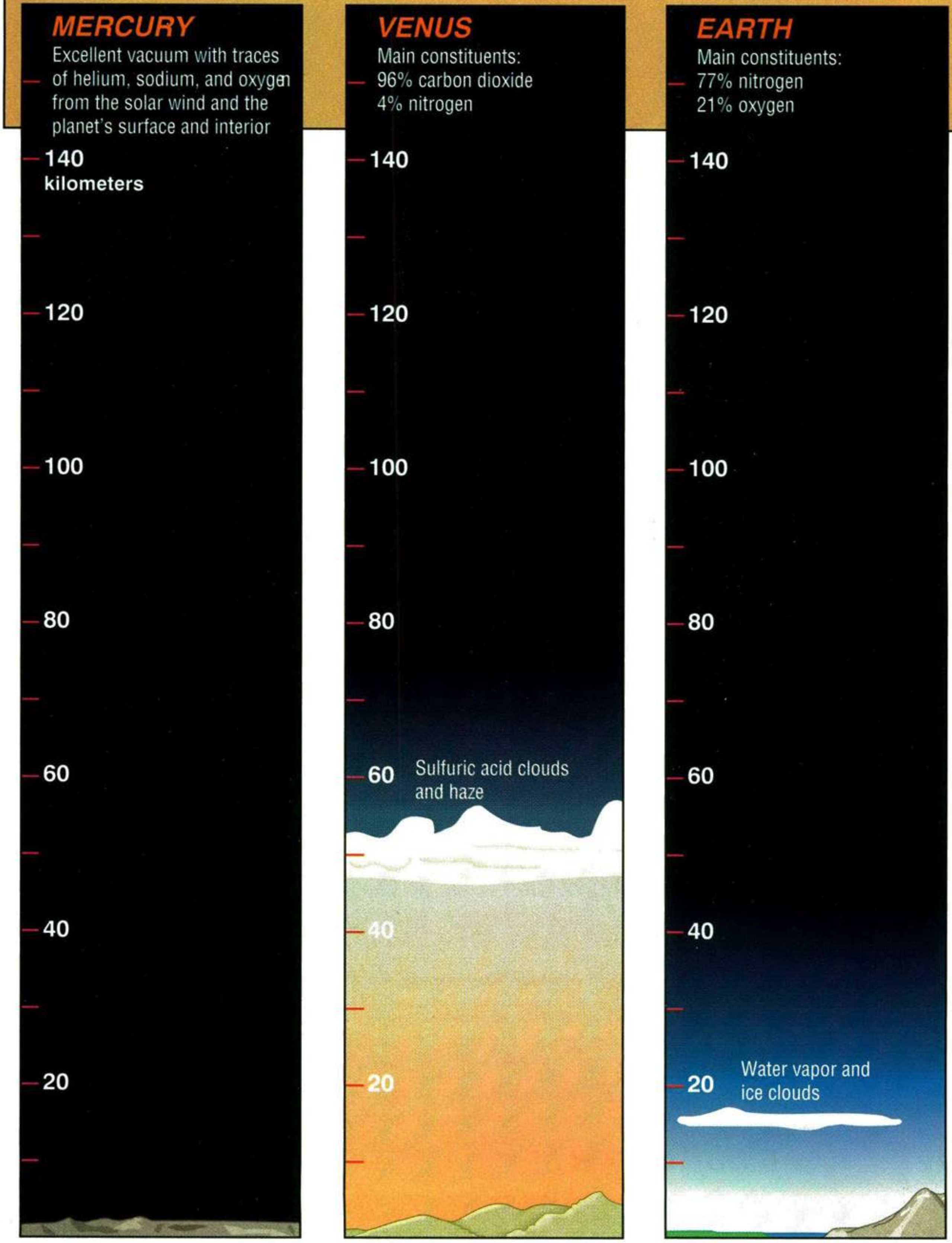


VENUS

Diameter: 12,102 kilometers
Surface gravity (Earth = 1.0): 0.88
Average temperature: 730 kelvins
Surface pressure (Earth = 1.0 bar): 90 bars
Main atmospheric constituents: 96% carbon dioxide, 4% nitrogen
Brief history of atmosphere: runaway greenhouse and loss of almost all water to space

Terrestrial Planet Atmospheres

Each terrestrial planet has evolved a different mix of gases that reflects mainly its initial conditions and partly its subsequent events.



MERCURY

Excellent vacuum with traces of helium, sodium, and oxygen from the solar wind and the planet's surface and interior

VENUS

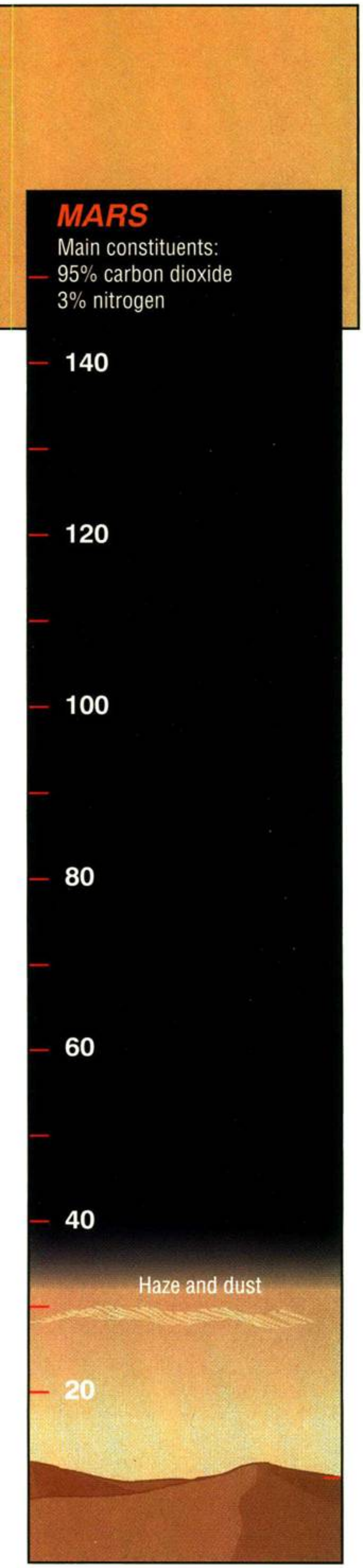
Main constituents:
96% carbon dioxide
4% nitrogen

Sulfuric acid clouds and haze

EARTH

Main constituents:
77% nitrogen
21% oxygen

Water vapor and ice clouds



on. We can then apply this estimate of activity to the reactive (and less directly traceable) gases to determine their production rate.

Michael Drake (University of Arizona), Thomas Bernatowicz and Bryan Hagee (Washington University), and I have been studying the behavior of neon, argon, krypton, and xenon in various mixtures of melted silicate rock and mantle minerals. We are seeking to understand how much noble gas would be picked up by magmas.

We have found to our surprise that magmas don't pick up much of these gases and thus are not efficient in transporting them. And when we extrapolate our laboratory results to the terrestrial atmospheres at large, we find we don't get the actual patterns of noble gases that space probes have seen in planets' atmospheres. This indicates that there hasn't been enough volcanic activity during the entire 4.6-billion-year age of the planets to account for the mass of their atmospheres!

If volcanic activity alone can't build today's atmospheres, then what can? The answer may lie in the solar system's infancy, its first billion years.

When we try to explore the history of our atmosphere, however, difficulties arise. Earth was born 4.6 billion years ago, but we have no record of conditions here prior to 3.9 billion years ago; tectonic recycling has erased it. While it is almost certain that in their early days Earth and the other planets were much hotter than today, scientists have no compelling evidence that volcanic degassing operated at much higher rates back then. But we know something did occur at high rates back then: impacts. The ancient cratered surfaces of Mars, Venus, the Moon, and Mercury all tell a tale of great numbers of planetesimals striking during the early days of the solar system — especially during a period called the late heavy bombardment, which ended between 4.0 and 3.6 billion years ago.

Researchers are now investigating the idea that the terrestrial atmospheres formed almost completely during the later stages of planetary accretion, which means they could consist largely of gases released during the impact of the larger planetesimals. Some of these scenarios are hair-raising.

Two investigators, T. Matsui and Y. Abe of Japan, first envisioned a growing Earth pounded by comets and water-rich asteroids and blanketed by a steam atmosphere 100 times heavier than today's. This dense, insulating cloud of water vapor would provide a super-greenhouse, trapping the heat of the impacts. Temperatures would be high enough for the Earth's surface to be completely covered by a sea of liquid rock. Then as the rate of impacts slowed, the planet cooled and the magma solidified into a proto-crust (now obliterated by tectonic activity). Cooling further, the steam eventually rained out to form our oceans.

According to this model, Venus (which formed similarly) never completely cooled off, so its steam atmosphere didn't condense. Instead, the water escaped with help from the Sun's ultraviolet radiation. Confirming evidence came from a more recent and more sophisticated study by Kevin Zahnle (of the Jet Propulsion Laboratory) and James Kasting and James Pollack (NASA's Ames Research Center). Their model produced a similar scenario, with the steam atmosphere at the Earth's surface peaking at 270 times today's pressure and a temperature of 800 kelvins. In addition, their model dissolved water and other gases in the magma ocean and buried them in the planet's interior, planting the seeds for today's volcanic outgassing.

Medium and large impacting objects, many of them volatile rich, would vaporize upon hitting a planet and add to the growing atmosphere. However, a really big impact might actually blow off more gas than it contributes. If the impact were large enough, the expanding vapor plume could escape the planet's gravity and dissipate into space. And if the plume were massive enough, it could drag along the column of atmosphere above the impact site.

At present, Mars has an average atmospheric pressure around 6 millibars (Earth's is about 1,000). Jay Melosh and Ann Vickery (University of Arizona) hypothesize that Mars once had an atmosphere with a pressure 100 times greater — roughly the same as Earth's — but lost most of it because of "impact erosion." This phenomenon would not be as pronounced for Earth and Venus because they are 10 times more massive and thus exert a stronger gravitational hold on their atmospheres.

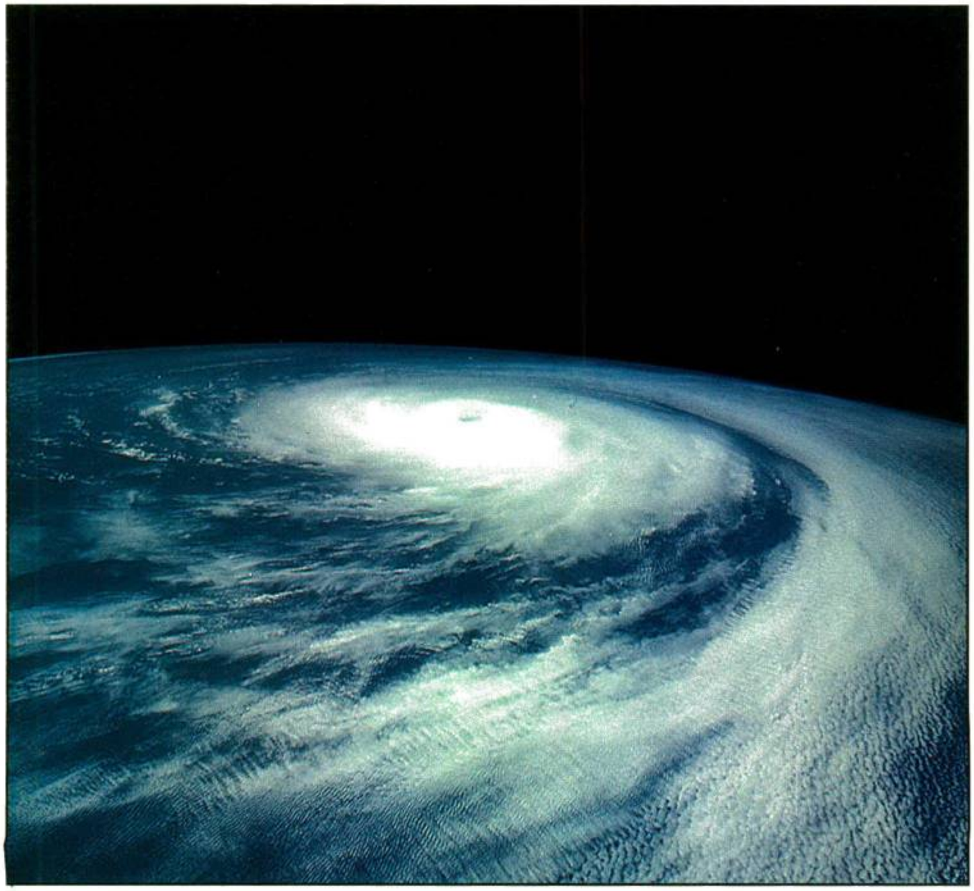
The solar system was born a long time ago, but today researchers can observe star-forming regions elsewhere in the Galaxy. These indicate that our Sun behaved very differently in the first few hundred million years of its life than it does now. The Taurus-Auriga dark cloud complex has been studied intensely, and the variable star T Tauri has given its name to a whole group of newborn solar-type stars. These young objects are throwing off mass at rates estimated to be a million times greater than the Sun's current rate — and one subtype (the FU Orionis stars) has periodic outbursts that are 100 to 1,000 times greater still. In its T Tauri phase, the Sun would have been like nothing seen since. Spinning rapidly and blazing with ultraviolet radiation, it would have raked the solar nebula disk with a powerful stellar wind.

Two teams of planetary scientists — Donald Hunten (University of Arizona), Robert Pepin (University of Minnesota), and James Walker (University of Michigan), and Zahnle, Kasting, and Pollack — have developed models to explain how energy from this powerful ultraviolet radiation could drive off the early hydrogen-rich atmospheres which the newborn terrestrial planets captured from the solar nebula. Under the effects of the T Tauri Sun, a supersonic hydrogen wind would flow off a planet, dragging other atmospheric molecules along.

These models all require a plentiful source of hydrogen. In the scenarios where young planets are blanketed with steamy atmospheres, hydrogen comes from the breakup of water molecules under the barrage of ultraviolet radiation. Hydrogen can also be produced from various chemical reactions on the planet's surface. Alternatively, the hydrogen in the escaping atmosphere could be primordial, composed of captured solar nebula gases. In any case, the powerful solar wind is a contributing player, sweeping up gas and dust from the atmospheres.

Diameter: 12,756 kilometers
Surface gravity: 1.0
Average temperature: 288 kelvins
Surface pressure: 1.0 bar
Main atmospheric constituents: 77% nitrogen, 21% oxygen
Brief history of atmosphere: moderate greenhouse, then absorption of most carbon dioxide into rocks and rise of oxygen from biological activity

EARTH



An interesting side effect of studying the noble gases is that their relative abundances differ from one planet to the next and differ as well from those of meteorites and the solar wind. This indicates that each planet contains a more or less unique mixture of chemical elements. In addition to noble gas abundances, there is also variation in the ratios between the different noble gas isotopes (their specific nuclear weights).

An atmosphere is like a big punch bowl in which nature stirs together a variety of ingredients in different proportions. Also, each "ingredient" contains its own set of isotopes in certain ratios, just as each kind of food we eat contains its own ratio of nutrients. In the case of the atmosphere, the final product is highly specific for a given planet. Scientists have measured the isotope ratios in the atmospheres of Earth, Mars, and Venus. Even taking into account the large range of error in the remote space probe measurements, the ratios on Mars and Venus still differ from Earth's.

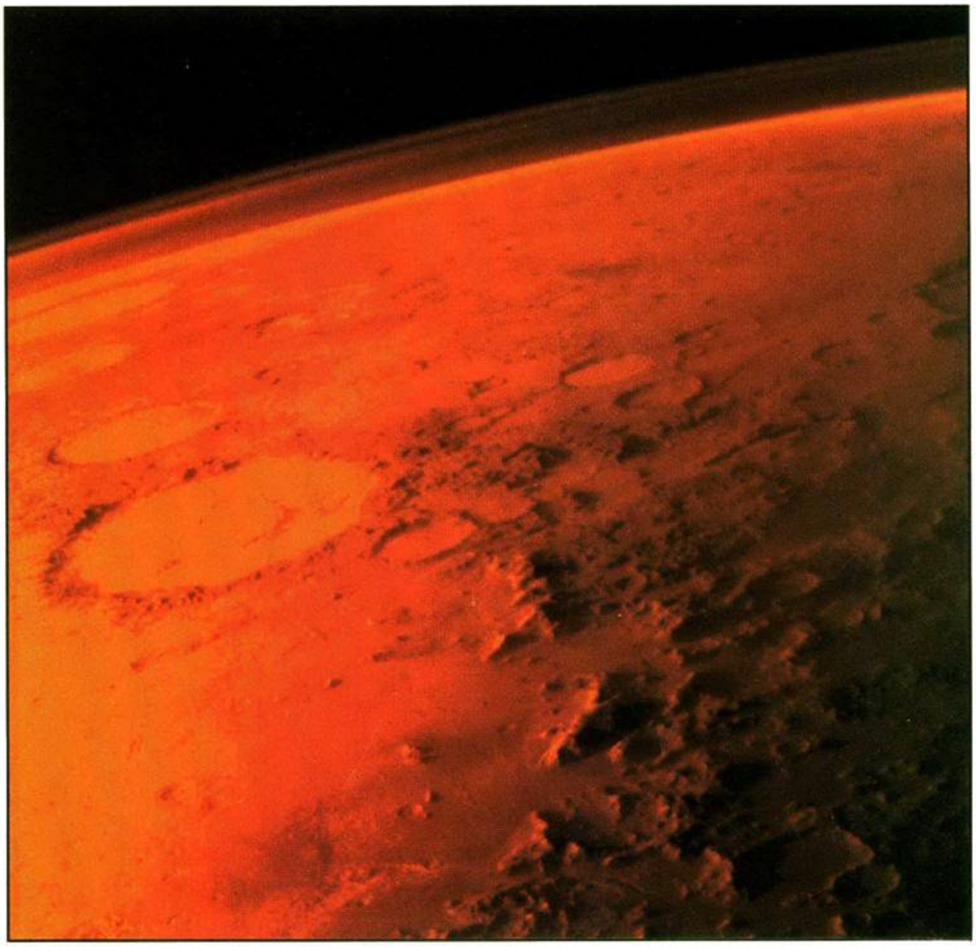
These ratios are not affected by volcanic degassing. It doesn't discriminate among the isotopes — all get belched out alike. Therefore to get a unique isotopic mix in an accreting planet, nature must either supply material to it with the right mixture or some process must selectively remove or create material to end up with the final mix. There is ongoing research across a number of fields to define not only the list of ingredients, but also the procedures that were followed in the noble gas isotopic recipe.

Scientists have also found that comet impacts could be highly significant. In fact, if only one percent of the material that accreted to make Earth arrived in the form of comets, all of our present atmosphere and hydrosphere can be accounted for. You start to wonder why the terrestrial planets are so dry! It's entirely possible that impacts and the solar wind stripped off most of the volatiles that belonged to the growing planets. The present atmospheres would then represent just a veneer from the final accreting material or the last big impacts. (In this light, it's tantalizing to consider the large number of organic compounds found in Comet Halley dust grains — and to wonder if comets supplied the precursor materials for the origin of life.)

Earth managed to keep its hydrosphere because temperatures are right for the survival of water, while Venus is dry today because liquid water isn't stable on its hot surface. Mars, however, is likely to have water hidden as subsurface ice. A few Martian channels formed after the end of the late heavy bombardment, and there are also surface areas similar to permafrost terrain on Earth. These point to more recent flows in which large amounts of water could have been introduced by comet or asteroid impacts.

After an impact, liquid water might have flowed briefly on the surface and then frozen. Alternatively, researchers such as Michael Carr (U. S. Geological Survey) and Virginia Gulick and Victor Baker (University of Arizona) argue that episodes of volcanism could melt subsurface ice, producing short-lived flooding and stream flows. So, at the other extreme, maybe Mars never had a dense atmosphere, and even the ancient channels were formed by reworking of ice deposits.

The outcome of present chemical studies is that the atmospheres of Earth, Mars, and Venus probably did not accumulate the way the textbooks say — by long periods of volcanic degassing. Instead, researchers are coming to a broad agreement that Earth's atmosphere (minus the life-derived oxygen) was established early, probably in the first few hundred million years of its history, and it's likely something similar happened to the other terrestrial planets. It is true that volcanic activity continues to the present, but this contributes to the atmosphere only in minor ways — and involves mainly volatiles that have been outgassed already and are being tectonically recycled.



MARS

Diameter: 6,786 kilometers
Surface gravity (Earth = 1.0): 0.38
Average temperature: 218 kelvins
Surface pressure (Earth = 1.0 bar): 0.006 bar
Main atmospheric constituents: 95% carbon dioxide, 3% nitrogen
Brief history of atmosphere: possible thick early atmosphere absorbed into rocks and ice caps and lost to space by impact

Noble gases can serve as inert markers to trace the development of a planet's atmosphere, but the message they give must be read with caution. While a planet may form in one part of the solar system with given noble-gas ratios, it probably also accreted material from many other parts of the solar system with "foreign" isotope ratios.

Scientists still have much work to do before we understand the origin and evolution of all the terrestrial atmospheres. More and better measurements of the Venusian and Martian atmospheres are absolutely necessary. Much could be learned, for instance, from close-up photography and core sampling of the high latitudes on Mars to determine if subsurface ice does indeed exist. In the meantime, researchers are continuing to experiment and theorize in the hope of drawing a more accurate picture of the solar system's distant past. ☐

Leigh Broadhurst is a planetary scientist at NASA's Goddard Space Flight Center in Greenbelt, Maryland. Her current research involves laboratory experiments with cometary-type ices.

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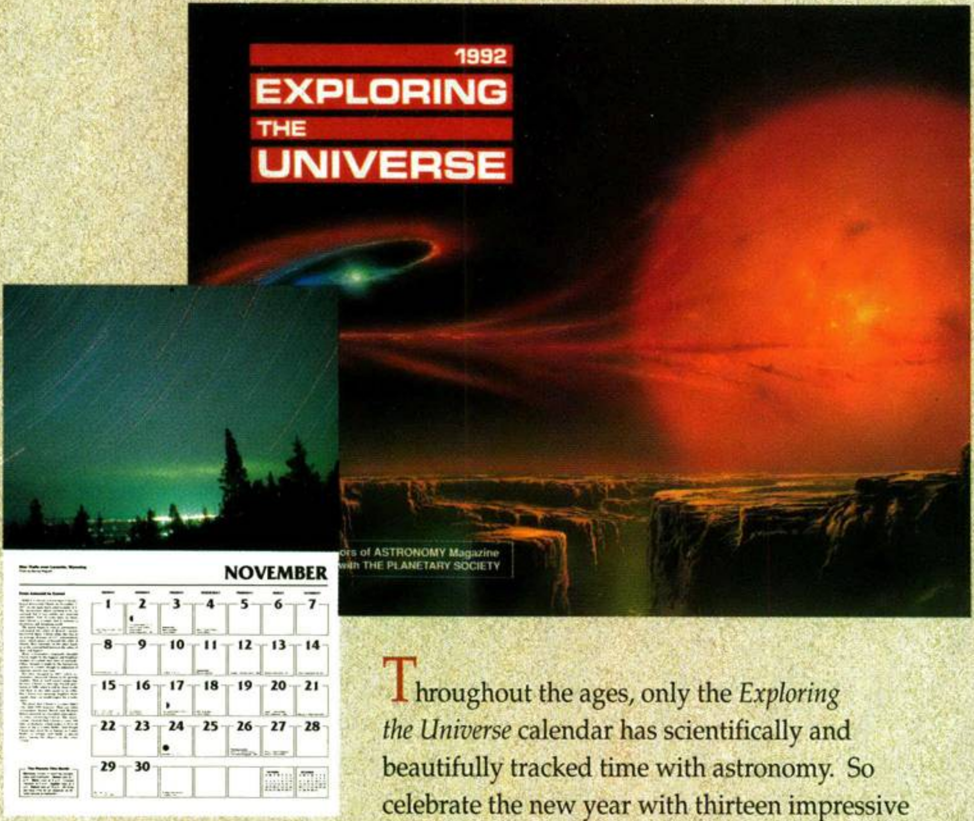

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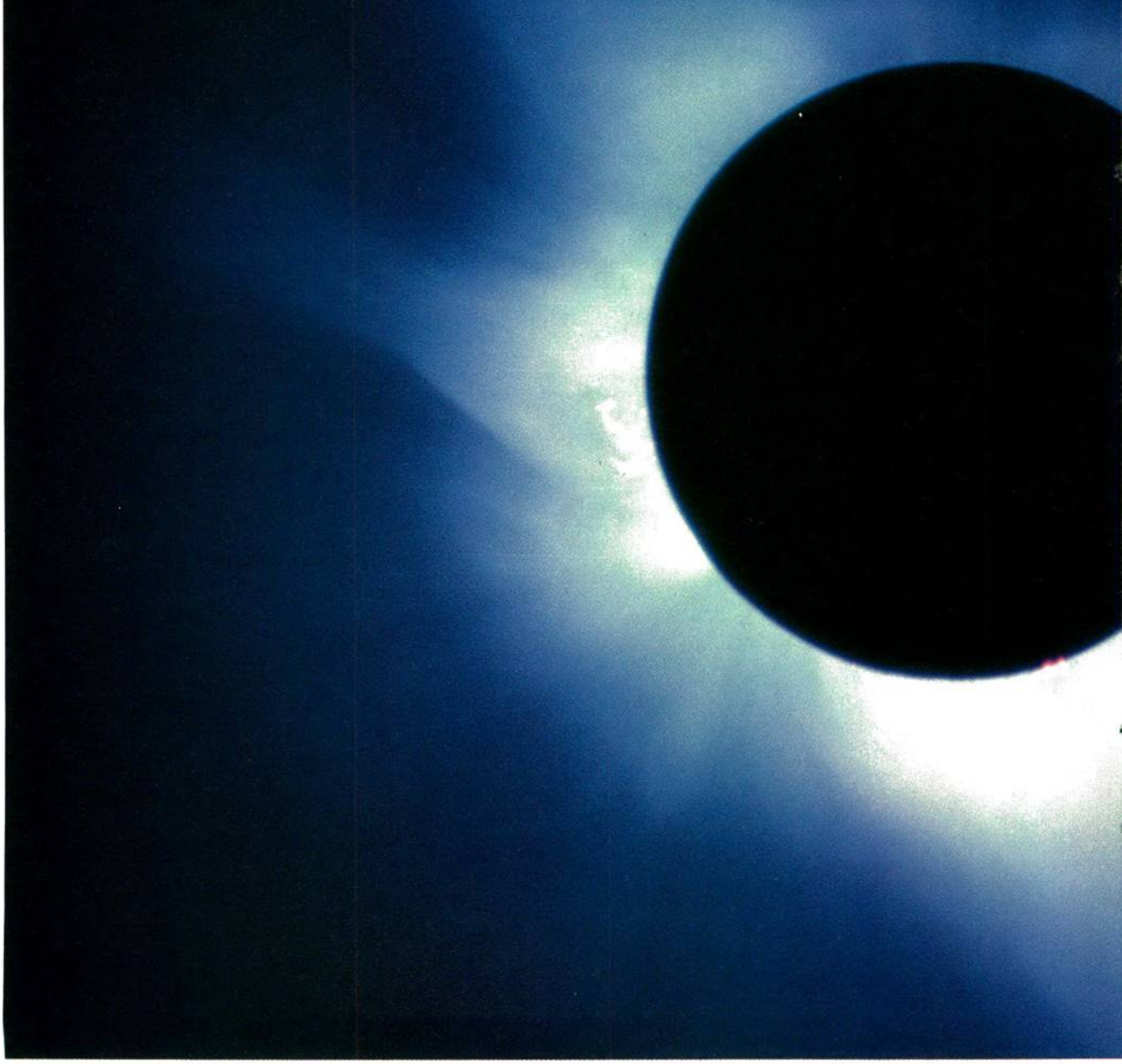
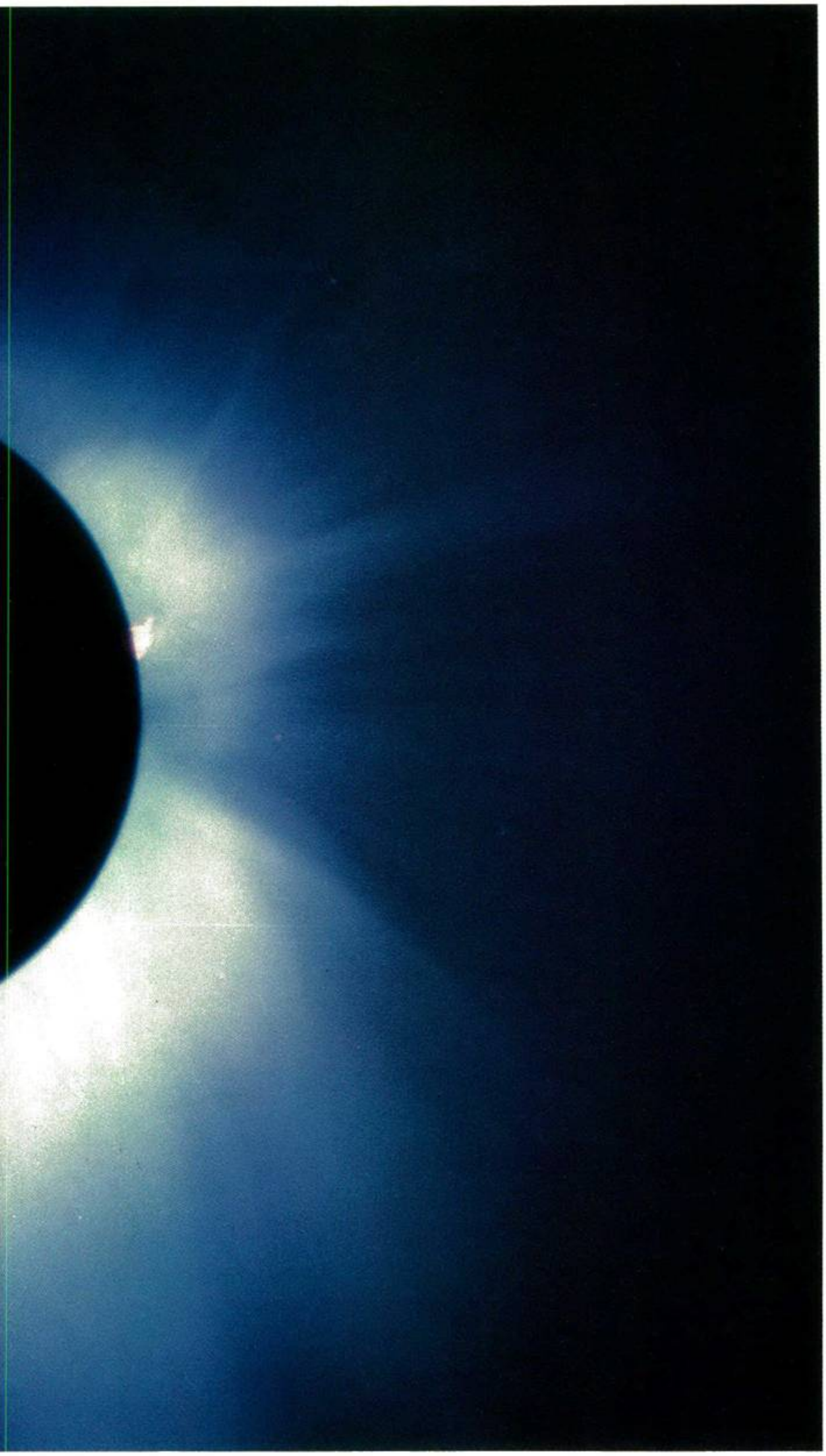


THE SUN

It was billed as a long, routine eclipse, but it surprised everyone. Here's a look at the extraordinary corona of July 11 and why it appeared the way it did.

by David Bruning



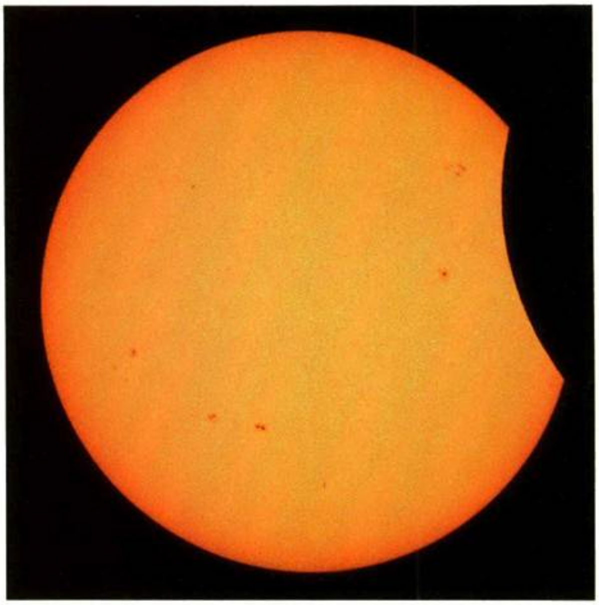
The Sun put on a spectacular show for thousands of onlookers last July. Vast helmet-shaped streamers stretched several times the Sun's diameter. Three large prominences appeared to leap from the Sun's surface. Coronal loops arced gracefully above the Sun's limb while high-latitude plumes radiated away from the polar regions. (See also the photographs in the October and November issues of ASTRONOMY).

Because the Sun was near the peak of its magnetic activity cycle (so-called solar maximum), most astronomers expected that the corona would look symmetrical. But the first surprise of this eclipse was the very asymmetrical appearance of the corona. The next surprise was the orientation of the largest streamers. Previous eclipses near solar maximum have shown minor asymmetry in the corona located along the east-west direction. However, for the July eclipse, the streamers were oriented more nearly north and south. What caused the corona to look so different at this eclipse?

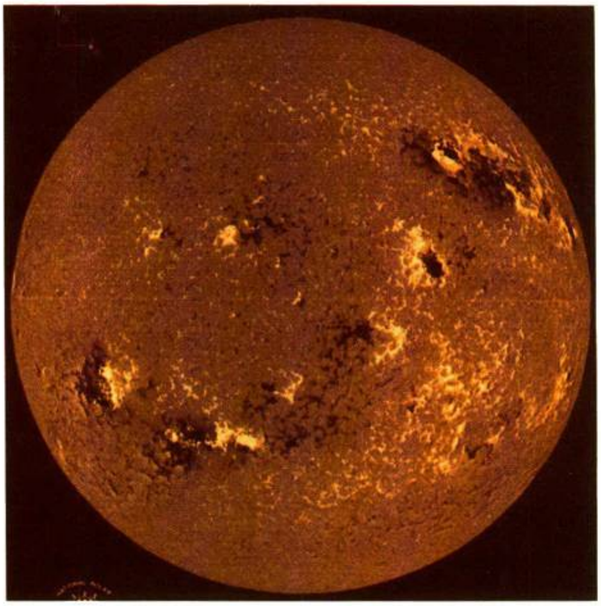
Shaping the Corona

Quiet, inactive stars have a rather weak, symmetric corona. What makes the corona of a star like the Sun complex and exciting is the presence of magnetic fields. But not just any magnetic field will do. The presence of concentrated regions of magnetic activity

THE CORONA APPEARS ASYMMETRIC in this photo by Ernie Piini. A dark coronal hole caused the gap seen at the top, and several streamers lie above prominences. (North is up and east is to left in all photos in this article.)



FIVE LARGE SUNSPOT GROUPS dot the Sun's surface as the partial phase of the eclipse starts. Only the group to the northwest (upper right) affected the structure of the corona. Photo by Alan Dyer.



MAGNETIC FIELDS appear in this magnetogram as white and black regions. Compare this image with the visible-light photo at left to see how much larger regions of magnetic activity appear than sunspot groups. National Solar Observatory image.

— so-called **active regions** — give rise to the most interesting of the coronal features.

The Sun generates magnetic fields deep in its interior. Through mechanisms not yet fully understood, periodically some of these fields erupt through the Sun's surface, the photosphere. The high temperature and structure of the corona are produced by energy pumped from the photosphere up into the outer layer of the Sun's atmosphere along these magnetic fields.

If magnetic fields were distributed evenly over the photosphere, the corona would be a uniformly bright sphere with no interesting structure. However, the magnetic fields on the Sun — and other active stars — prefer to erupt in isolated regions. As an active region grows in size, one or more sunspots develop in the region. The sunspots appear dark because the intense magnetic field which passes through the sunspot prevents heat from flowing through that part of the photospheric gas. Features in the corona are produced as ionized gas above the active regions is gathered by the magnetic field. These features appear bright because energy flowing along the magnetic field heats the gas.

Structures called **coronal loops** form right above an active region. The loops connect regions of opposite magnetic polarity (like the north and south poles, or ends, of a compass). Coronal arches are much larger looplike features that extend between two active regions.

Prominences form at the junctions between different polarities in an active region and thus visibly mark the position of the magnetic neutral line. The small, short-lived (minutes to hours) sprays and active prominences are found in strong, young active regions that have large sunspots in them. Loops and sprays are often triggered by the explosive release of energy of a flare and can rise a considerable distance above the Sun's surface. Long-lived prominences (those of several months) are sometimes called filaments. They are found in old active regions that have diffuse magnetic fields. Filaments are typically large, extending over a substantial portion of the Sun's disk, and have a hedgelike appearance when viewed edge on.

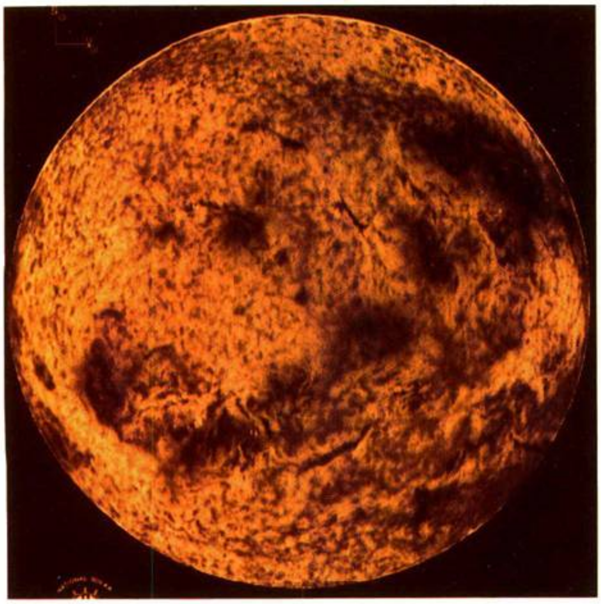
Helmet streamers (named after spiked helmets once common in Europe) form over the neutral lines in large active regions with a long-lived prominence commonly embedded in the base of the streamer. The footpoints of the streamer are in the regions of opposite polarity so the streamer itself straddles the prominence.

During an eclipse, the visible portion of a streamer extends several times the Sun's radius out from the photosphere. But recent measurements suggest that streamers may reach at least halfway to Earth. The lower portion of the streamer arcing over the prominence has a closed magnetic field because the field loops from one polarity region to another. Higher up, the magnetic field is drawn out into interplanetary space. Gas flowing out along these open magnetic fields helps to create the solar wind.

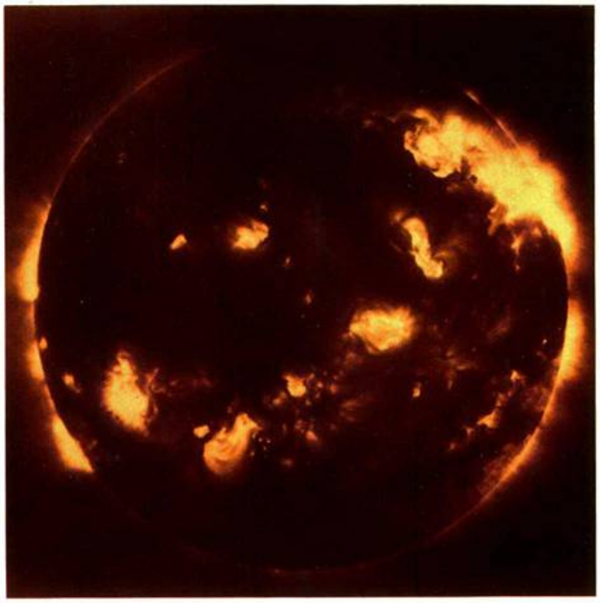
Another large-scale coronal feature is the **coronal hole**. The low density of the gas makes this part of the corona appear dark, as if there were a hole in the corona. The hole is created by a large region of a single magnetic polarity that opens into the corona and extends out into space. Particles from the Sun stream along the open magnetic field to form the high-speed part of the solar wind.

Coronal holes form during the evolution of active regions. As a region ages, the two magnetic polarities separate. One polarity moves toward the equator where it eventually disappears. The other polarity slowly migrates toward the nearest pole of the Sun. Before it reaches the pole, though, the magnetic field from this large single polarity region opens into space, forming a coronal hole.

When the region reaches the pole, it helps to reverse the polarity of the magnetic field there, contributing to the stately rhythm of the 22-year solar cycle. Over the course of the cycle, the poles of the Sun change magnetic polarity every eleven years. The polarity change generally occurs about the time of maximum sunspot activity, which led astronomers to conclude that the solar activity cycle was 11 years long.



PROMINENCES AND CORONAL HOLES appear as dark filaments and whitish regions, respectively, in this photo taken in the infrared light of helium (He 10830). National Solar Observatory image.



CORONAL LOOPS rise above the Sun's surface in this x-ray image of the inner corona. Compare the loops at the limb in this image with those in the photo on page 48. Smithsonian Astrophysical Observatory and IBM/Research image.

Recently, astronomers have discovered that two sets of sunspots are present on the Sun's surface. Low-latitude spots and active regions represent the magnetic polarity of the present half of the 22-year cycle, while high-latitude spots and regions contain the polarity of the next half of the cycle. It is useful, though, to continue to use the 11-year cycle of sunspot numbers to describe the maximum and minimum phases of solar activity. The Sun is still near maximum in its current cycle of sunspot activity. Scientists expect the broad maximum in this cycle, which started in 1989, to continue well into 1992. As a result, a large number of sunspots and active regions appeared on the Sun's surface on the day of the eclipse.

Eclipse Day Sights

On July 11, five large sunspot regions dotted the Sun's surface (see page 50, left). But the Sun was considerably more active than this number implies. Researchers can view the active regions with a special device called a magnetograph, which measures the magnetic splitting of a spectral line. An image, or magnetogram, obtained with this device shows strong magnetic fields as black or white depending on the polarity of the magnetic field. The quiet, weakly magnetic photosphere with its salt-and-pepper pattern of mixed polarity appears largely gray in a magnetogram.

The magnetogram for July 11 (see page 50, right) shows that there were six large active regions and a number of smaller ones. There was a particularly large active region near the west limb of the Sun (at right in the photos). The small sunspot group seen in the white light photograph belies the complexity of the active region.

The white-light photograph and magnetogram show what happened in the photosphere on that day and give us an idea roughly where coronal loops and arches would appear. To determine the locations of prominences, streamers, coronal holes, and other large-scale structures higher in the Sun's atmosphere, we can look at images taken in other regions of the Sun's spectrum. For example, the helium spectral line at 10830 angstroms forms in the chromosphere, the layer just above the photosphere. The He 10830 line is also sensitive to radiation from the corona and, thus, should begin to show low-lying structures in the corona.

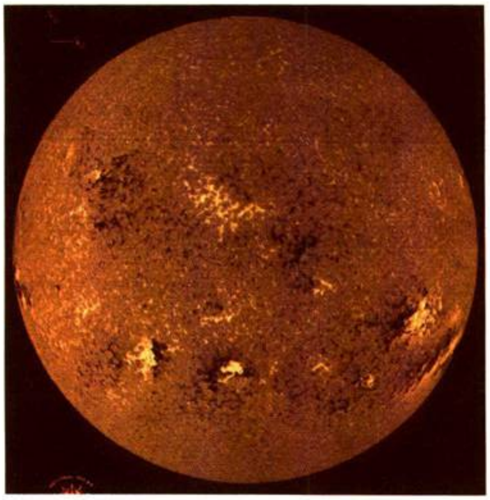
Since He 10830 forms in absorption, the active regions and prominences appear in a photograph (see above left) as dark features against the brighter, mottled gray of the quiet chromosphere. We see prominences as long dark filaments against the Sun's disk, while dark loops seem to arc above the active regions.

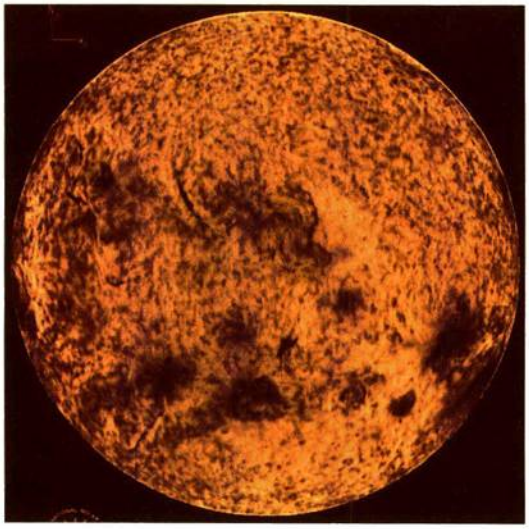
Coronal holes also appear in this photo, one large one along the east limb (to the left), one at each of the poles, and one near the equator at the west limb. The low density of the coronal hole means there is little absorption in He 10830 compared to the quiet chromosphere. So the hole appears less black than the gray of the chromosphere, or whitish in a He 10830 image. Comparing this photo with the magnetogram shows the diffuse single-polarity magnetic regions (grayish on the magnetogram) generating the hole.

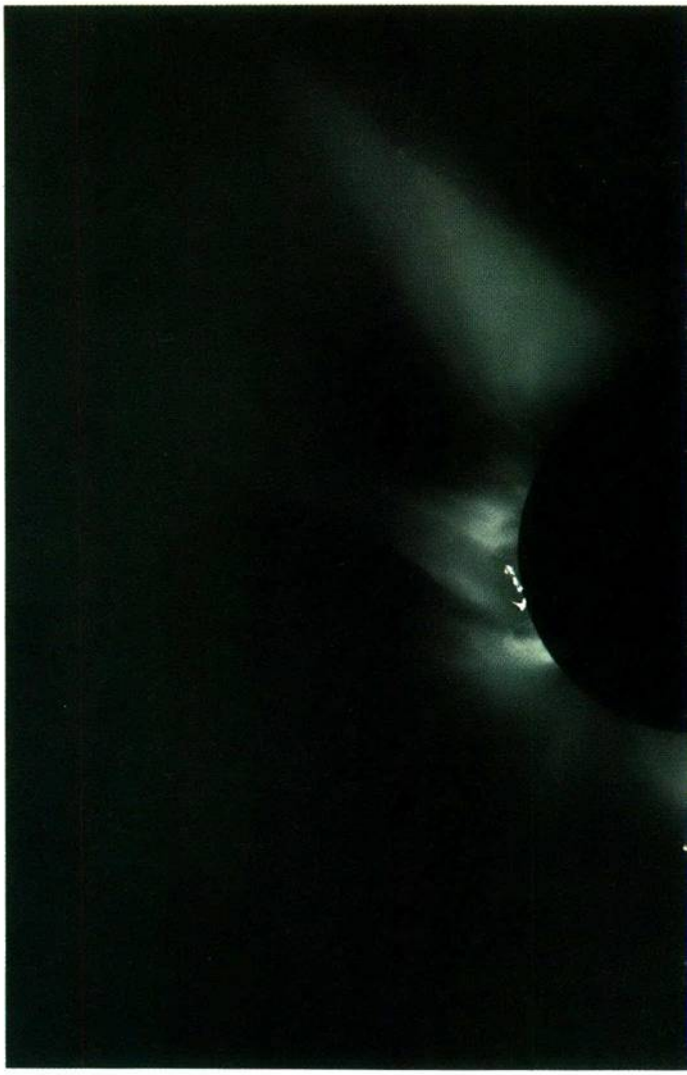
One of the reasons for the corona's unusual shape on July 11 is the positions of the coronal holes. The dark coronal holes caused the gaps in the corona at the north pole, the west limb near the equator, and to the southwest.

Astronomers can image the corona directly using x rays. An image obtained from a rocket launched above New Mexico on the day of the eclipse shows the lower corona (above right). Coronal holes appear black in this image. White loops in the corona trace the magnetic field above the active regions, although we don't easily see in this photo the fainter arches connecting different active regions. The wispy structures at the east and west limbs of the Sun are loops extending above active regions that have not yet rotated onto or have just rotated off the visible side of the Sun. Some of these x-ray loops have larger counterparts that are visible in the eclipse photos on pages 48 and 52-53.

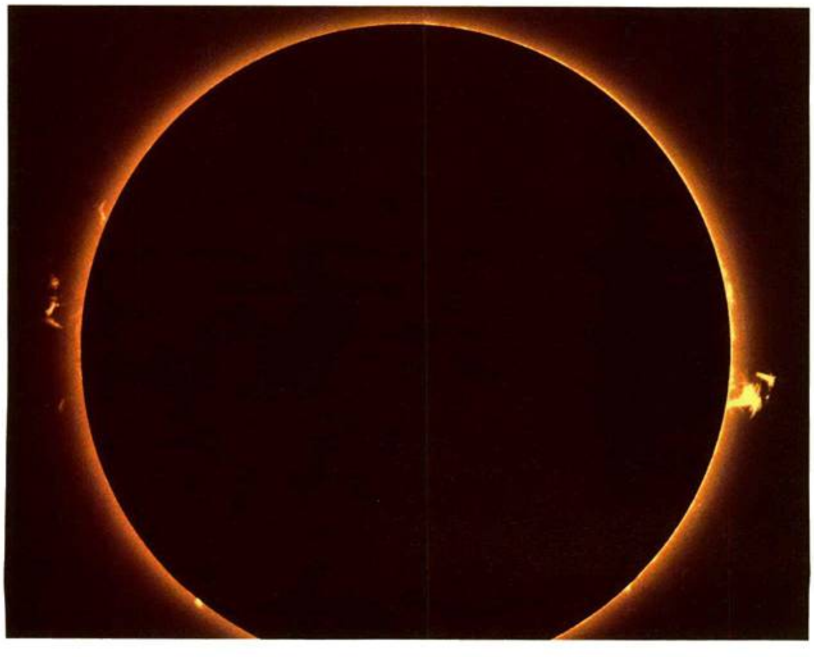
In the x-ray image, we see neither helmet streamers nor the prominences over which the streamers







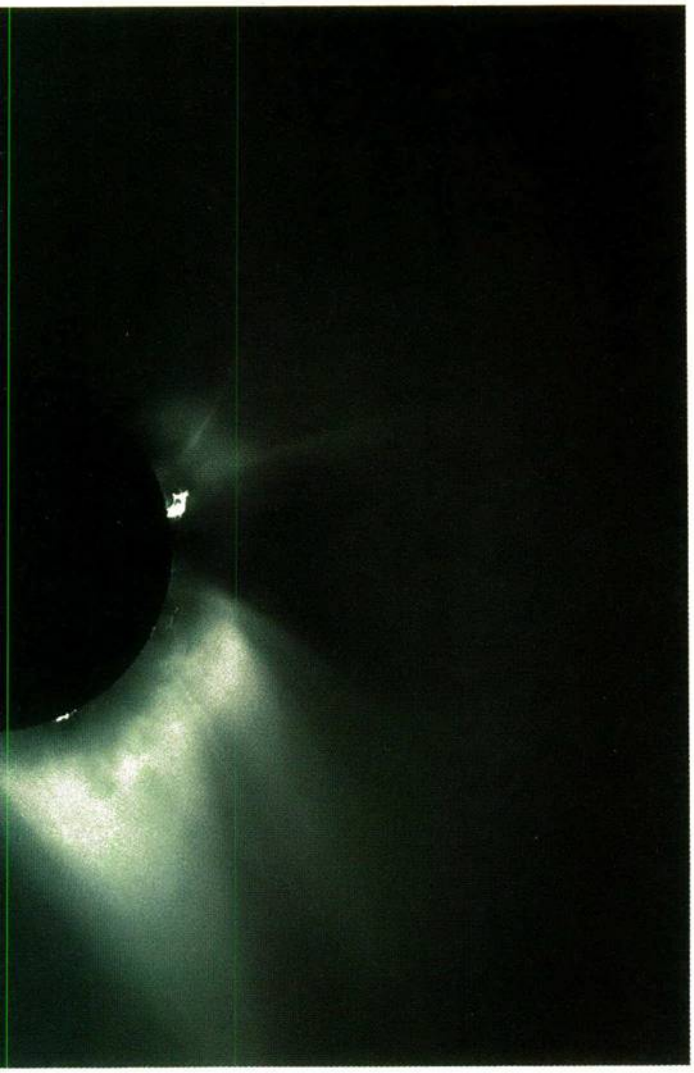
EAST-LIMB FEATURES in the photo (above right; Rhodes College/HAO) correlate with features seen seven days later near the Sun's central meridian in the magnetogram (top) and He 10830 image (above). The prominence at left in the hydrogen-alpha photo (below) generated a small streamer. National Solar Observatory images.

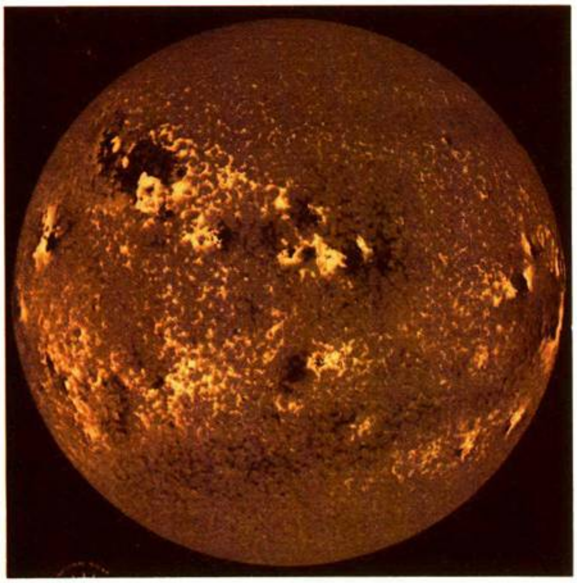


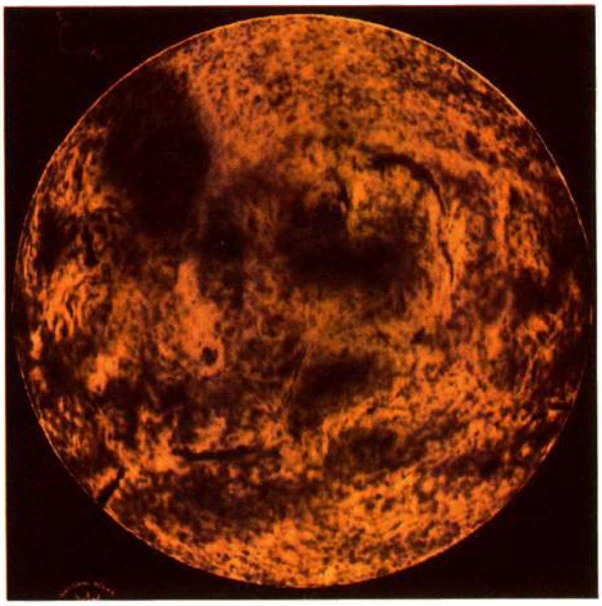
form. The gas in the prominence itself is too cool to radiate x rays, and the gas immediately surrounding the prominence in the corona is not very dense. So the x-ray image is most useful for finding coronal loops and arches, while the He 10830 image best shows the prominences and, thus, possible helmet and streamer locations. When x-ray images aren't available, magnetograms can be used to find the active regions and infer coronal loop positions.

Although we have identified the coronal loops and coronal holes at or near the limb, the other active regions and prominences on these photos produced coronal features that the Moon's disk covered during the eclipse. Unfortunately, the active regions and prominences at the limb aren't visible in this set of photographs.

Luckily, there is a way to see what these regions look like thanks to the long lifetime of most active regions and filament-type prominences. The Sun's rotation will eventually bring the regions







ON THE WEST LIMB are the fast-changing "seahorse" prominence, a smaller prominence, and its helmet streamer. The west-limb polar coronal hole appeared in the magnetogram (upper right) and He 10830 image (right) July 4. National Solar Observatory images.

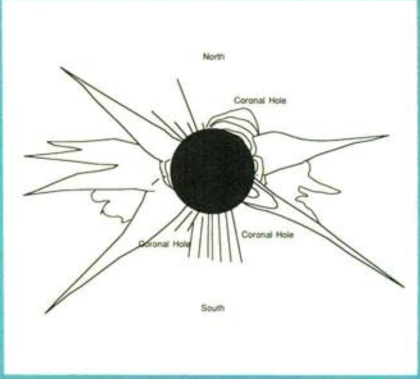
presently at the east limb to the central meridian — an imaginary straight line connecting the Sun's north and south poles — where it is easier to view the region. This one-quarter of a solar rotation takes about seven days. To see the regions that were on the east limb on July 11, we can look at the regions near the central meridian on July 18. The regions near the central meridian on July 4, seven days before the eclipse, will show us what regions were at the west limb during the eclipse.

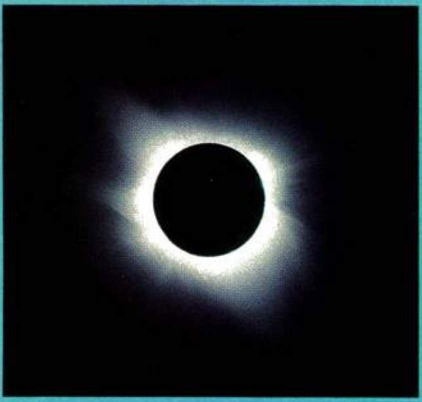
Structures seen in the corona can be related to photospheric regions at the limb, or slightly in "front" or "behind" the limb features. The low density of the coronal gas permits us to see these "foreground" and "background" regions. So prominences and active regions near, but on either side of, the central meridian in the photographs taken seven days before and after the eclipse may contribute to the corona's appearance.

West Side Story

Looking at the July 4 magnetogram (above), you can see there are only two main active regions, one just north of center and one south of center. The northern region spawned the "seahorse" prominence, although this prominence is not visible in the helium 10830 image. The seahorse was an active prominence, suggesting it formed sometime just before the eclipse. (It was not visible in He 10830 images taken two days before the eclipse.) It isn't surprising that the seahorse was so active. This region produced extensive flare activity in June, and active prominences commonly accompany the flare activity.

You can see the changing appearance of the prominence by comparing its appearance in the two eclipse photos and the hydrogen-alpha prominence picture (page 52 bottom left). There isn't a streamer related to this prominence because it is not a long-lived prominence. But there are some curved filaments visible in the eclipse photos at this location. Filaments, or plumes, and dark rifts are believed to form in coronal holes, so the large hole in the north may have produced this feature. Or possibly the feature was related to the active region since active regions can form spike-shaped streamers. Adding to the structure of the corona in this area, there was a coronal mass ejection in this region just hours before the eclipse. Perhaps a lifting of the





PREDICTING THE CORONA'S SHAPE

"Coronal forecast for July 11, 1991: several large helmet streamers, three significant coronal holes, polar rays along the Sun's south pole, sparse polar rays in the north, with possible eruptive phenomena along the northwest limb." Patrick McIntosh forecast the corona's shape based upon several months of solar images made in the red light of hydrogen and in the infrared light of helium (10830 angstroms). McIntosh, a solar astronomer at the National Oceanic and Atmospheric Administration's Space Environment Lab, made his prediction on July 6. You can see for yourself how well he did by comparing the photo (bottom left) with his prediction (top left).

McIntosh examined the helium 10830 images for the presence of coronal holes to infer positions along the Sun's limb that might appear dark on eclipse day. He predicted helmet streamers above long-lived prominences that were going to be at or near the Sun's limb, while the presence of high-latitude prominences implied the existence of polar rays.

He based his forecast of eruptive phenomena in the northwest upon record-breaking flare activity in this region in June. Flares are explosive releases of energy and usually mark changes in the magnetic structure of the active region. Occasionally, an ejection of mass from the corona accompanies flares. As if on McIntosh's cue, a coronal mass ejection took place about 10 hours before the eclipse. Some viewers saw the last vestiges of the ejection in the northwest during the eclipse.

Diagram by Patrick McIntosh and photo by Michael Stecker.

long-lived prominence seen to the northwest of solar center in the July 4 He 10830 image caused the mass ejection.

The southern group apparent in the July 4 magnetogram provided some of the large loops seen in the x-ray image and the eclipse photos. But the large helmet streamer was related to the large prominence observed to the southeast in the July 4 He 10830 image. This prominence is still seen in the July 11 He 10830 image just moving off the visible disk. Our view of the prominence along its length rather than sideways where the full extent of the prominence would be visible caused the squat appearance in the eclipse and prominence photographs (page 52, bottom left). The presence of this high-latitude prominence and its streamer in part gave the corona its asymmetric appearance.

Looking East

Several different regions affected the appearance of the east limb corona. As seen in the magnetogram for July 18, an active region to the south generated some loops, but since there was not an accompanying prominence, no streamer was visible. The coronal hole in the south (see the He 10830 image for July 18) probably gave rise to the weak plumes seen in the southeast.

A short prominence is located just above this active region. But this is not the same prominence seen on eclipse day. The large prominence seen at the east limb on eclipse day was very active — so active that it wasn't seen one day later. The prominence seen in the He 10830 image for July 18 merely formed later in the same region. As seen in the eclipse photos, a streamer formed over the east limb prominence. But the magnetic field geometry suggested by the magnetogram for July 18 suggests that the streamer was twisted, giving it its unusual shape.

Most enigmatic of the east features was the large streamer to the northeast. A long-lived, large prominence should have been related to this streamer, but none was seen even one day later. This helmet streamer is apparently one of the exceptions and merely formed above two adjacent regions of magnetic polarity. A prominence may have once been in this region, but is no longer visible.

Was It a Surprise?

Yes, the shape of the corona was a surprise. It was expected to be nearly symmetric, typical of the corona of eclipses seen at the maximum of the solar cycle. The three large prominences were certainly a treat, but the streamers oriented more nearly north-south than east-west gave this eclipse its really unusual appearance. (More than one astronomer tried to place the streamers east-west before determining the true orientation of north in the photo!)

Had this eclipse occurred two years ago at the start of solar maximum, the corona would have been more nearly symmetric. The reason: the Sun had more prominences more evenly spaced across its surface. But there was a smaller number of prominences for the July 11 eclipse. As a result, there were fewer helmet streamers to dominate the corona. The three or four regions producing streamers and the coincidence of several coronal holes appearing near the limb produced the unique spectacle for the "eclipse of the decade." ☐

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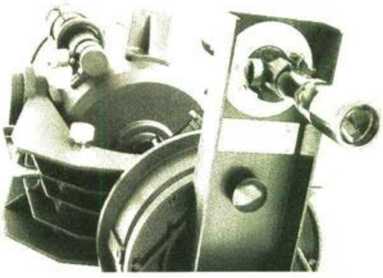

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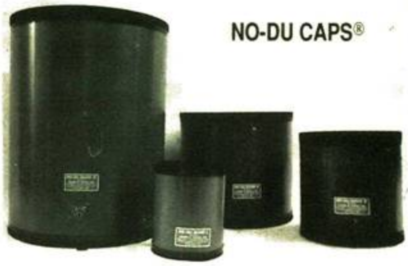

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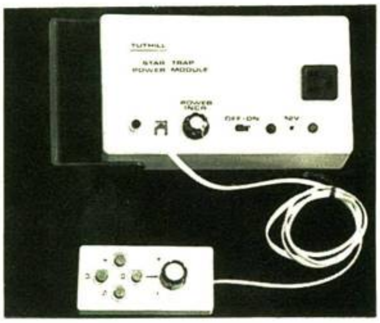

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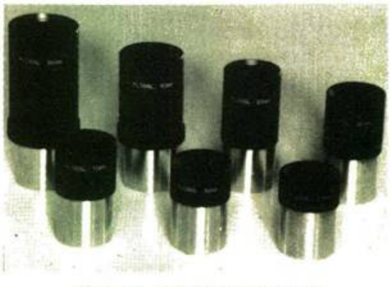

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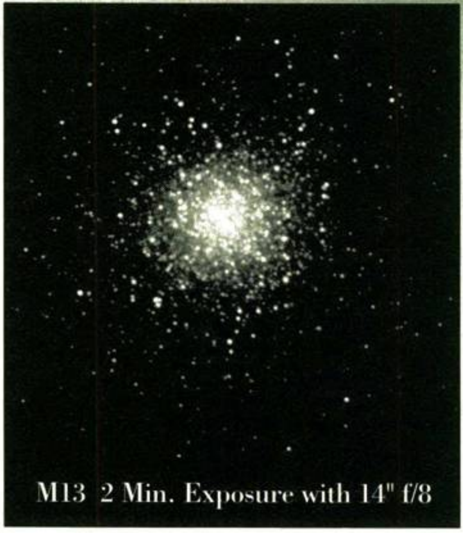
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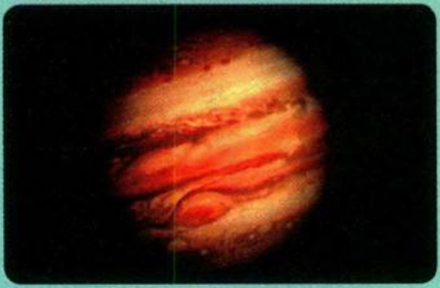

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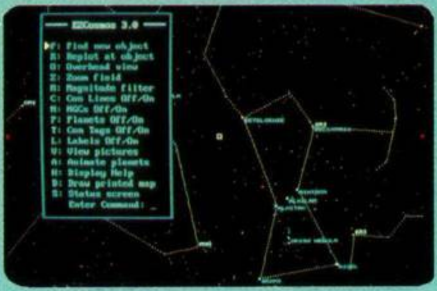

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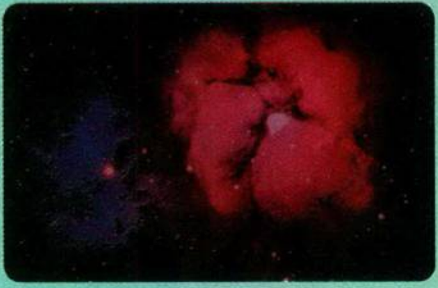

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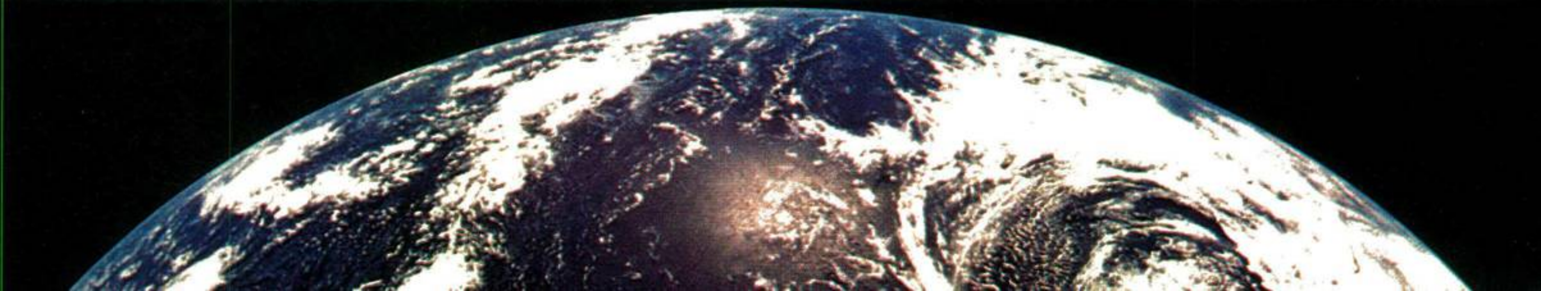
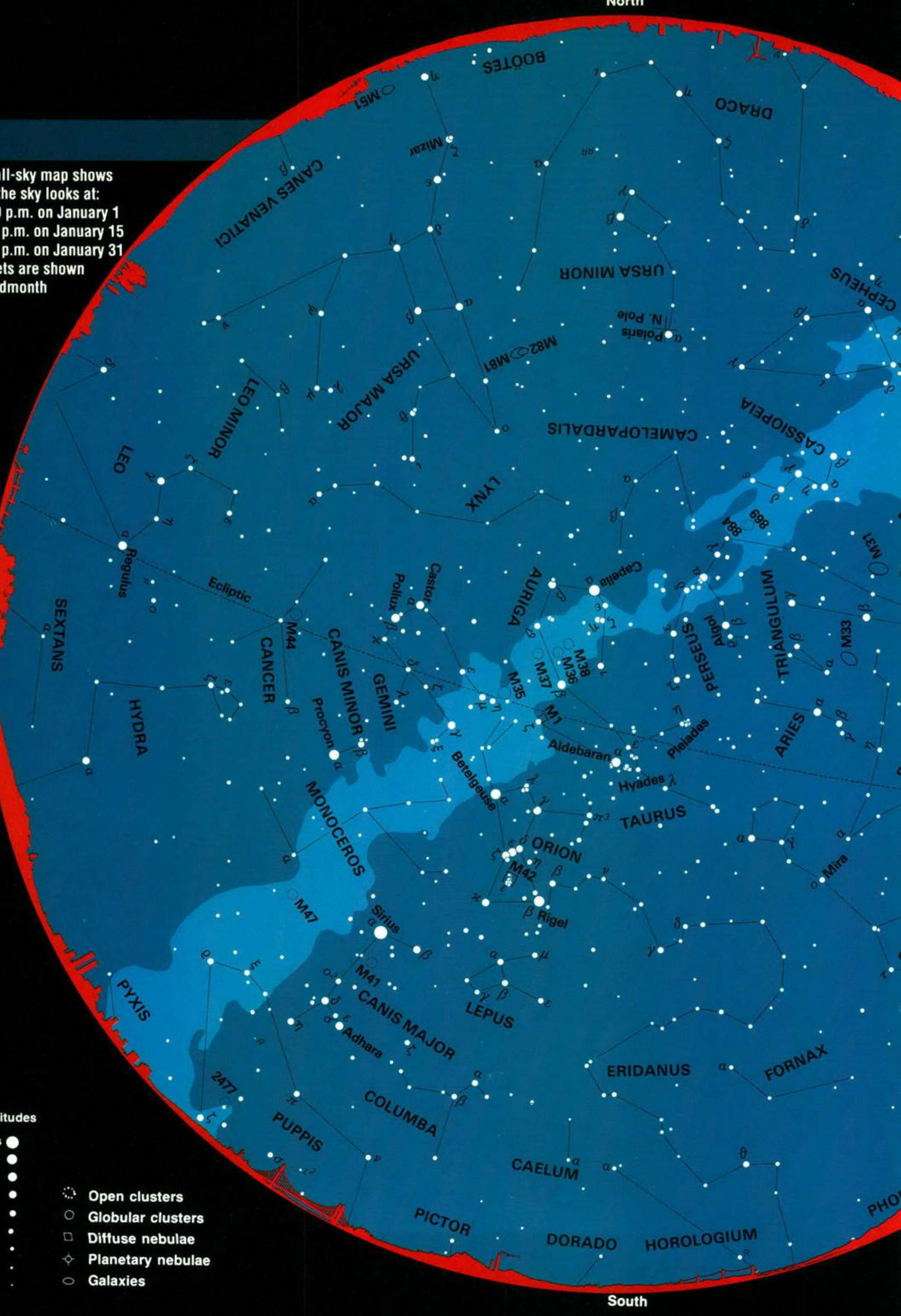
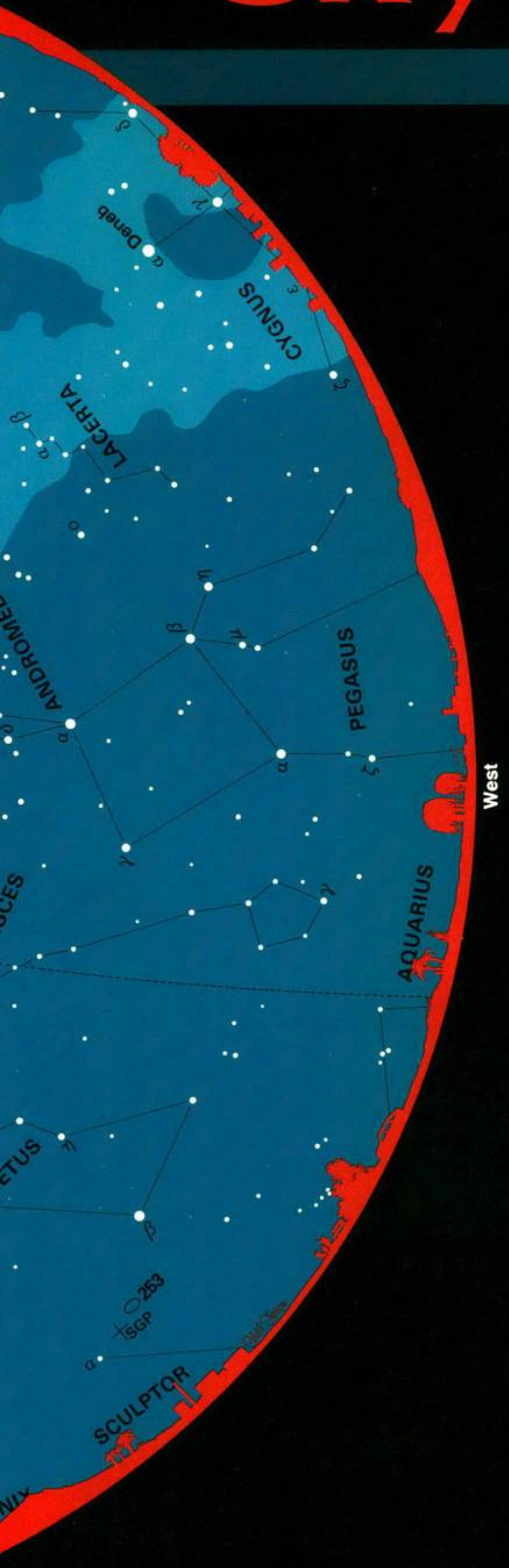


The all-sky map shows
how the sky looks at:
10:00 p.m. on January 1
9:00 p.m. on January 15
8:00 p.m. on January 31
Planets are shown
at midmonth


North
South
East
BOÖTES
M51
DRACO
Mizar
CANES VENATICI
URSA MINOR
CEPHEUS
N. Pole
Polaris
M82
M81
URSA MAJOR
LEO MINOR
CASSIOPEIA
CAMELOPARDALIS
LEO
LYNX
869
884
M31
Regulus
Ecliptic
Castor
Pollux
AURIGA
Capella
TRIANGULUM
SEXTANS
M44
CANCER
CANIS MINOR
GEMINI
M38
M36
M37
M35
PERSEUS
Algol
M33
HYDRA
Procyon
M1
ARIES
Aldebaran
Pleiades
Betelgeuse
Hyades
TAURUS
MONOCEROS
ORION
M42
Mira
M47
Sirius
Rigel
M41
PYXIS
CANIS MAJOR
LEPUS
Adhara
ERIDANUS
FORNAX
2477
COLUMBA
PUPPIS
CAELUM
PICTOR
DORADO
HOROLOGIUM
PHO
Magnitudes
Sirius
0.0
0.8
1.6
2.4
3.2
4.0
4.8
5.6
Open clusters
Globular clusters
Diffuse nebulae
Planetary nebulae
Galaxies

Sky Almanac

January 1992



Map Art by Wil Tirion

ANNULAR ECLIPSE ON JANUARY 4

Observers across the western third of North America will witness a partial solar eclipse as the Sun sets on the afternoon of January 4. For those along the coast of southern California, the Moon passes directly in front of the Sun and creates a sensational annular eclipse — in which all of the Sun except for a thin ring around the lunar limb is blocked from view.

QUADRANTIDS PEAK ON JANUARY 4

One of the best, though least observed, annual meteor showers reaches its peak before dawn on January 4. If you have clear skies that morning, you could be treated to dozens of bluish meteors leaving long trails across the cold, dark sky.

MARS IS BACK

After a three-month hiatus while it passed slowly behind the Sun, Mars returns to the morning sky in January. The Red Planet lies low in the southeast half an hour before sunrise when you can spot it against the gathering dawn.

Calendar of Events

1 The Moon passes 5° south of Venus, 7 a.m. EST

2 Asteroid Amphitrite is at opposition

The Moon passes 3° south of Mercury, 8 p.m. EST

3 The Moon passes 0.8° south of Mars, 5 a.m. EST

Earth is at perihelion (91.4 million miles from the Sun)

4 Quadrantid meteor shower peaks

New Moon is at 6:10 p.m. EST; annular solar eclipse

Uranus is in conjunction with the Sun

6 The Moon is at apogee (252,569 miles from Earth), 6:41 a.m. EST

The Moon passes 3° north of Saturn, 6 p.m. EST

7 Neptune is in conjunction with the Sun

10 Mercury passes 0.6° north of Mars, 3 p.m. EST

12 First Quarter Moon is at 9:32 p.m. EST

19 Full Moon is at 4:28 p.m. EST

The Moon is at perigee (221,550 miles from Earth), 5:14 p.m. EST

21 Asteroid Massalia is at opposition

26 Asteroid Flora is at opposition

Last Quarter Moon is at 10:27 a.m. EST

29 Mars passes 0.4° south of Uranus, 4 p.m. EST

Saturn is in conjunction with the Sun

31 The Moon passes 1.0° south of Venus, noon EST

Eye on the Sky by Deborah Byrd

AN ECLIPSE OF THE ANNULAR KIND

As the Sun sets over the western third of North America on January 4, observers with clear skies and an unobstructed western horizon will see a solar eclipse. Although most eclipse watchers will see a partial eclipse, observers along the coast of southern California will witness an annular eclipse just as the Sun sinks into the Pacific Ocean. (For more details on observing the annular eclipse, see "Eclipse at Sundown" in the December issue.)

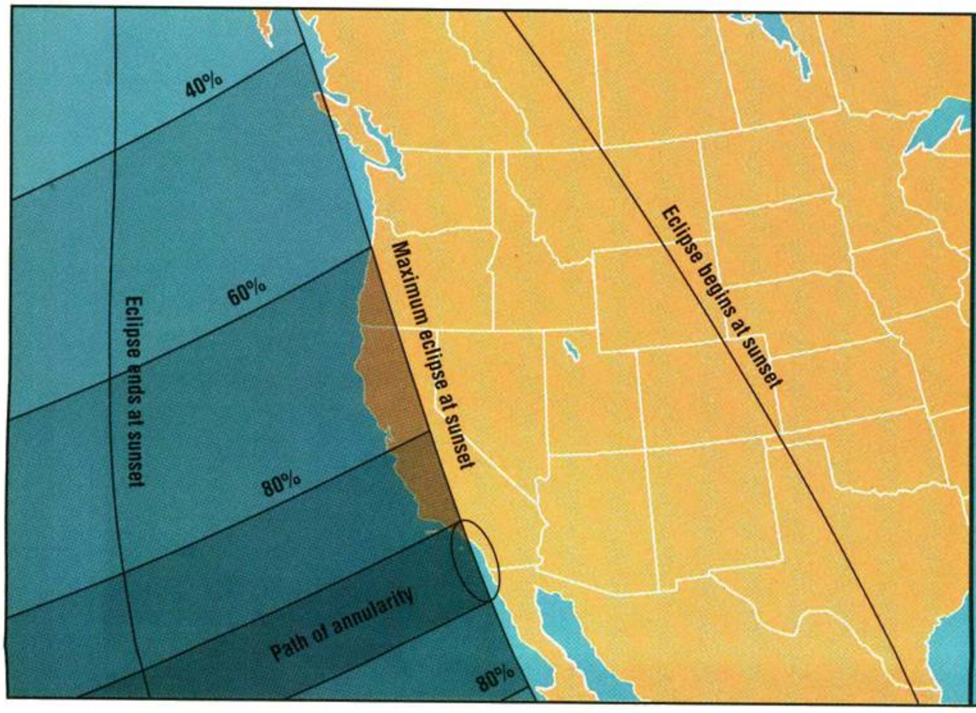
An annular eclipse gets its name from the Latin word *annulus*, meaning ring. It occurs because the Moon's orbit around Earth isn't a perfect circle. The Moon has a closest point to Earth each month (called perigee) and a farthest point (apogee). Although it's hard to tell just by looking with the naked eye, the Moon at apogee is a bit smaller in our sky than the Moon at perigee. If the Moon passes directly in front of the Sun while near apogee — as it does in January — its disk is too small to cover the solar disk completely and a portion of the Sun's surface shines in a ring around the Moon.

An annular eclipse is essentially a partial eclipse. AT NO TIME CAN YOU LOOK DIRECTLY AT THE SUN without risking permanent eye damage. You can safely view the eclipse through #14 welder's glass or an aluminized Mylar filter. Unfortunately, you probably won't be able to project the eclipsed Sun's image through a pinhole — it will be too dim because the Sun is so near the horizon.

A MORNING OF METEORS

The Quadrantid meteor shower peaks on the morning of January 4, the same day as the solar eclipse. That means the Moon — whose light can wash out a meteor shower — will be nowhere in sight at the shower's peak. Still, the Quadrantids are tricky to observe. The peak of the shower is very narrow, lasting only a couple of hours. What's more, the experts disagree on the exact time of the peak. If you go outside on the morning of the 4th, you may be treated to a fabulous display of a hundred meteors per hour. Or, you may see only a dozen or so meteors. In either case, the Quadrantids typically

THE ECLIPSED SUN SETS over Puget Sound in Jim Rostirolla's photo of the July 21, 1990 eclipse. Observers throughout the western United States will be treated to a similar view at sunset on January 4. Map by Fred Espenak, NASA/Goddard Space Flight Center.



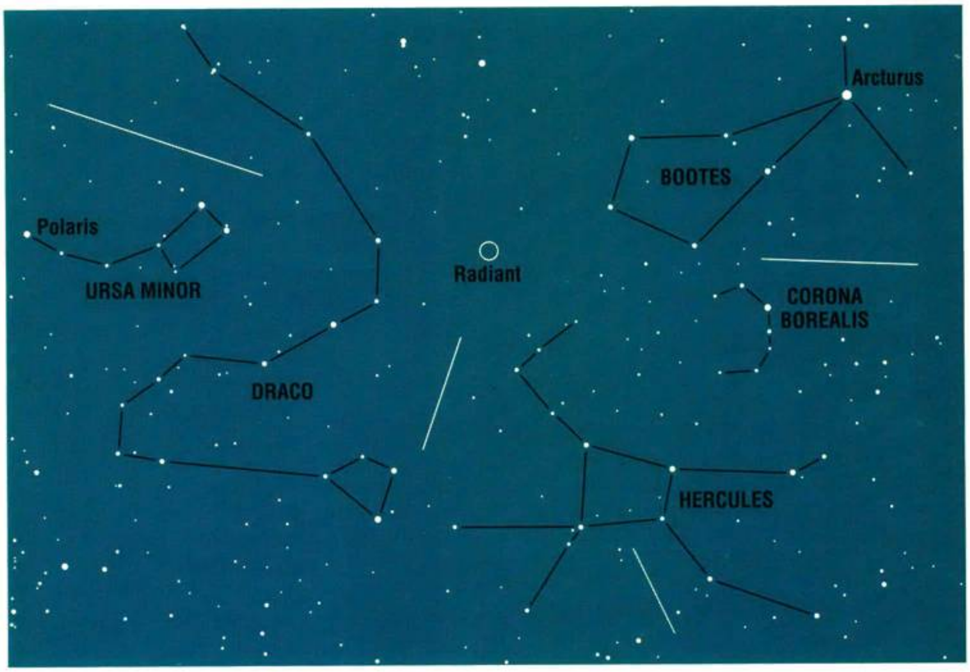
TIME AND PERCENT OF MAXIMUM ECLIPSE

City	Local Time	Percent Eclipsed
Albuquerque	5:03 p.m.	28
Anchorage	3:02 p.m.	14
Boise	5:16 p.m.	50
Calgary	4:36 p.m.	7
Denver	4:43 p.m.	7
Fresno	4:51 p.m.	84
Honolulu	2:09 p.m.	67
Las Vegas	4:34 p.m.	71
Long Beach	4:53 p.m.	92
Los Angeles	4:52 p.m.	92
Phoenix	5:29 p.m.	62
Portland	4:35 p.m.	59
Sacramento	4:49 p.m.	78
Salt Lake City	5:08 p.m.	40
San Diego	4:51 p.m.	92
San Francisco	4:49 p.m.	78
Seattle	4:25 p.m.	52
Tucson	5:27 p.m.	58
Vancouver	4:21 p.m.	47

appear blue and many leave long silver trains.

Meteor showers are named for the constellation from which the meteors appear to radiate. But you won't find a constellation that begins with the letter Q in any star atlas. The Quadrantids are named for a constellation that no longer exists — Quadrans Muralis. The stars of this obsolete constellation are now divided among Bootes, Draco, and Hercules.

The best place to watch a meteor shower is under a dark sky. Just remember that the Quadrantids take place at the coldest time of the year. Warm clothing is essential — you might even try wrapping yourself in a sleeping bag to ward off the cold. Some coffee, tea, or hot chocolate will also help you to stay warm.



BRIGHT BLUISH METEORS will streak across the predawn sky on January 4 as the annual Quadrantid meteor shower reaches its peak. The meteors will appear to radiate from a point high in the northeast near the intersection of Bootes, Draco, and Hercules.

MARS SAYS HELLO

After being lost in the Sun's glare for several months, Mars returns to the morning sky at the start of the New Year. But it doesn't exactly make a grand entrance. The Red Planet appears low in the southeast before dawn and shines quite dimly at magnitude 1.4. Still, you can find Mars fairly easily when the month begins, below and to the left of two other members of our solar system, brilliant Venus and innermost Mercury. The waning crescent Moon joins the scene on January 1 — an old Moon for the New Year.

Before Mercury drops back into the Sun's glare, Mars and the innermost planet fleetingly share the same right ascension. Their conjunction takes place on January 10, when Mercury lies 0.6° north of Mars and shines at magnitude –0.3. After Mercury disappears in the Sun's glare around midmonth, Mars continues ascending in the southeastern sky. It will continue climbing slowly away from the dawn as Earth inches ahead of it in its smaller and faster orbit around the Sun. An entire year will pass before Earth finally passes between the Sun and Mars and the planet appears at its best.

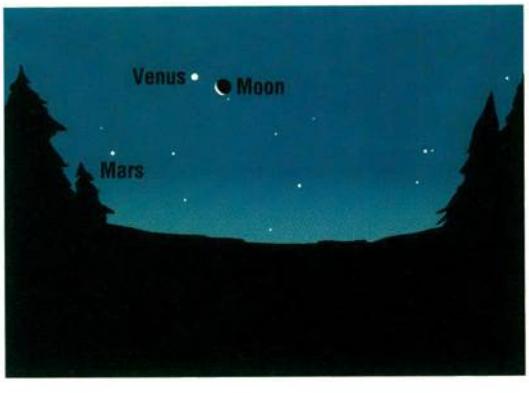
JANUARY'S PLANETS

Saturn is very low in the southwest after sunset in early January. To catch a glimpse of it, you'll need a western horizon free of clouds and other obstructions. Try looking for Saturn on January 6, when it lies near the young Moon. Although the planet is fairly bright at magnitude 0.6, it's nearly overwhelmed by the bright twilight. By mid-January the Sun wins out, and Saturn disappears. It will return in mid-February, this time in the east-southeast before dawn.

As Saturn gets ready to leave the evening sky, Jupiter prepares to take its place. The giant planet rises in mid-evening when the month begins, a very bright light among the background stars of Leo. At magnitude –2.3 this month, Jupiter is nearly at its brightest for the year. Yet it isn't as well-placed for viewing as it will be in another month. By late February, Jupiter will be rising in the east just as the Sun sinks in the west, a bold rival to winter's bright stars.

The other naked-eye planets reside in the morning sky during

MARS RETURNS to the morning sky in January, appearing low in the southeast about 30 minutes before sunrise. Make a note to look for the Red Planet on the 31st, when it lies to the lower left of the Moon and Venus.



January. Venus shines brilliantly at magnitude –4.1 in the southeast. It lies above Mercury and Mars when the month begins and appears far more noticeable than either of those planets. The waning crescent Moon lies near Venus twice this month — passing 5° south of the planet on January 1 and just 1° south on January 31.

THE STARRY SKY

On a dark winter night, when the Moon is down and you're standing beneath a country sky, look to the southeast for the elusive constellation Monoceros, the Unicorn. Monoceros lies in the midst of a triangle formed by the two Dog Stars, Sirius and Procyon, and the bright red star Betelgeuse in Orion. The famous stargazer Leslie Peltier once said he saw a "stiff-legged hobbyhorse" in the stars of the unicorn. But most of us looking toward Monoceros will see only a few faint, scattered stars.

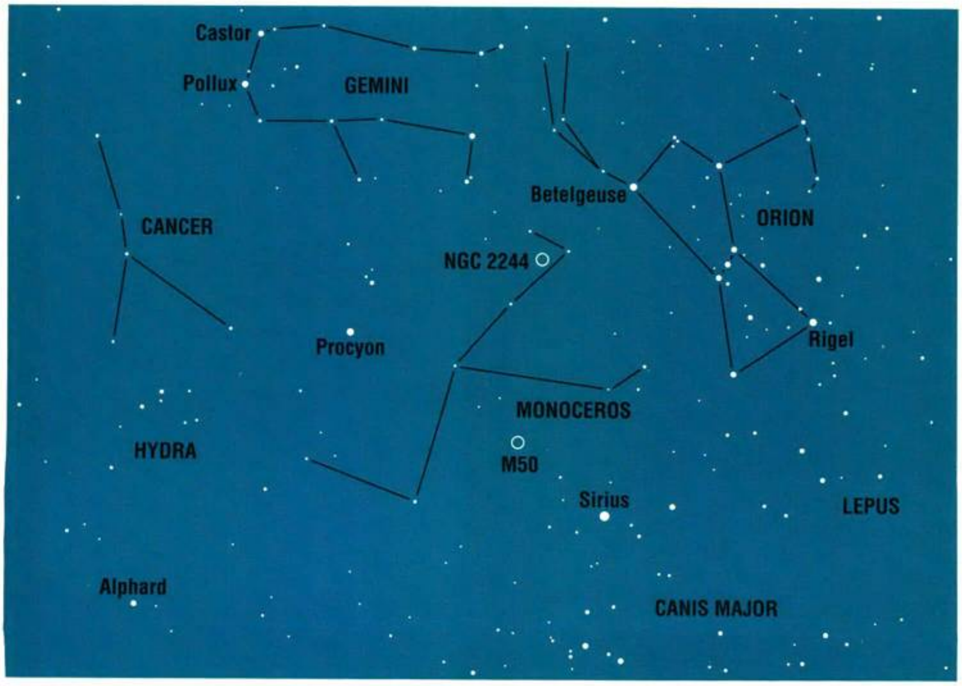
Astronomers disagree over whether Monoceros is one of the ancient constellations. I found it on a list of constellations said to have been invented by Bayer in the early 17th century. But some claim it was invented around the mid-1500s and others say it has been found pictured on relics from ancient Persia. There are many legends about unicorns, but most people recall that they can only be lured into captivity by the gentleness of a young girl. Another ancient legend says that the horn of a unicorn renders poison harmless.

Like all unicorns, Monoceros has its own magic. A faint, narrow portion of the winter Milky Way runs behind the constellation, and thus it contains a number of fine open star clusters. When looking at Monoceros, be sure to use your binoculars so you can take in more of what the constellation has to offer.

In 1772, Charles Messier noted a smudge of light located a little more than a third of the way along an imaginary line drawn from Sirius to Procyon. He assigned the number 50 to this little smudge, which turned out to be a cluster of several hundred stars. M50, as it's generally called, is now known to lie nearly 3,000 light-years from Earth. Its total magnitude is 5.9, making it barely visible to the naked eye under ideal conditions. With binoculars, however, this cluster is easy to find.

Another good binocular target in Monoceros is NGC 2244. It consists of a 6th-magnitude star with fainter stars clustered around it. Like M50, NGC 2244 is an open star cluster. Surrounding NGC 2244 is one of the sky's best photographic targets — a remnant of the cloud from which these stars formed — which we call the Rosette Nebula. These stars and their residual nebula are estimated to be 5,500 light-years away. It seems fitting to me that Monoceros is so hard to spot and yet, like all parts of the heavens above, so full of wonders. ☐

SURROUNDED BY WINTER'S BRIGHT STARS, the celestial unicorn Monoceros is easy to *locate*, but dim enough that it's difficult to *see*. In January, Monoceros lies about halfway up in the southeast during the late evening.



Deborah Byrd is writer, coproducer, and cohost of the nationally syndicated radio series Earth and Sky.

AN ANNULAR SOLAR ECLIPSE

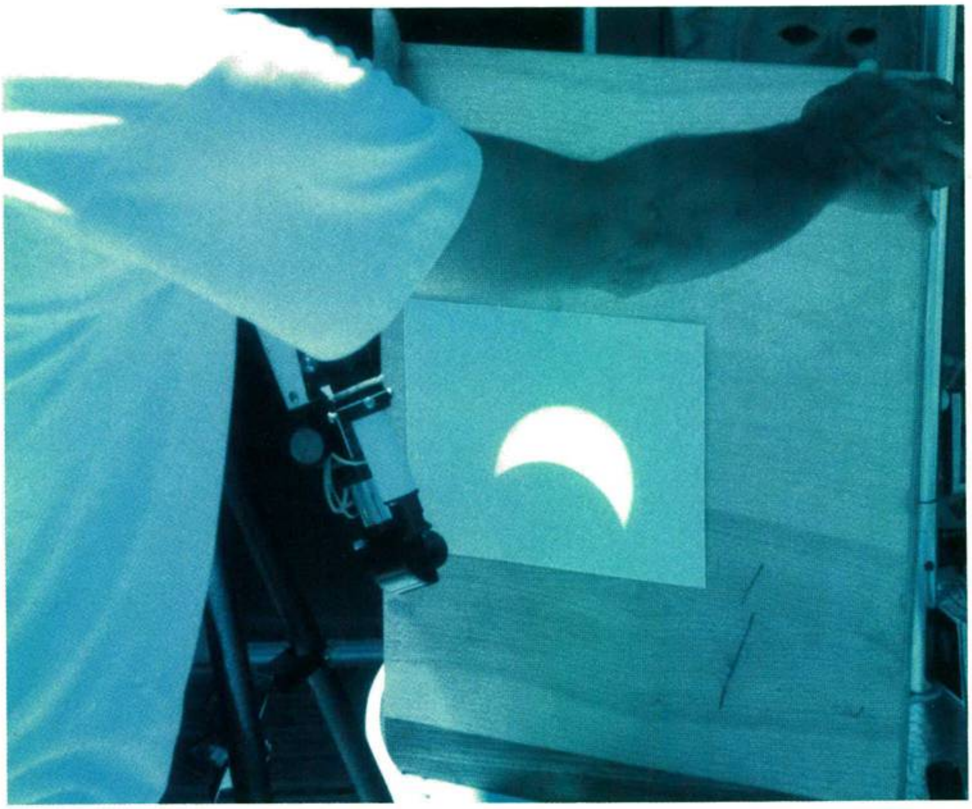
The big event this month is the annular solar eclipse on January 4, which reaches the coast of southern California around sundown. If you live in the Los Angeles area, think about taking your scope to Santa Monica or Redondo Beach and watching the eclipsed Sun vanish into the blue Pacific. Given skies clear of smog and haze, it should make for a striking, one-of-a-kind sunset!

The eclipse begins on the west coast at about 3:30 p.m. PST, with the Sun just 15° above the horizon. Annularity occurs an hour and twenty minutes later, at 4:50 p.m. PST. Observers along the coast north and south of the path of annularity will witness a partial eclipse as the Sun sets, while observers in the Hawaiian Islands will see a partial eclipse around 2 p.m. local time. (For more information on the annular eclipse, see "Eclipse at Sundown" in the December issue; details on the partial eclipse can be found on page 60.)

One of the easiest and safest ways to observe an eclipse is to project the Sun through a telescope. Use a moderate-power (and inexpensive) eyepiece, one that will render a complete disk of the Sun. An eyepiece with slightly over a half-degree true field, for example, should be fine. Tape a large piece of white drawing paper to a piece of stiff cardboard and temporarily mount it so you can project the Sun on to it from your eyepiece. If possible shield the screen from the glare of ambient sunlight or arrange your observing position so the screen is in shadow.

Now find the Sun in the telescope by orienting the tube so that it casts the smallest possible shadow on the ground. Then make small adjustments until the Sun's image is cast on to the screen.

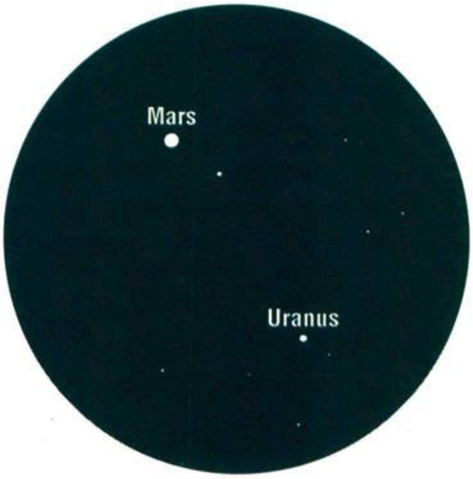
Two important safety tips. It's a good idea to cover the objective periodically to prevent damaging the optics (that's the reason for the cheap eyepiece). And keep your finderscope capped. You won't need it, and uncapped, it's a hazard to eyes, flesh, and facial hair.



VIEW THE JANUARY 4 ECLIPSE SAFELY by projecting the Sun's image through your telescope onto a piece of white paper. Photo by Bob Burt.

Another safe way to observe the eclipse is to use an over-the-aperture mylar filter, which you can get from most telescope dealers. You will still want to use moderate magnification (although now you can use a better eyepiece) and you should locate the Sun in the same way. But you will observe the image directly, with eye to the eyepiece. Mylar filters, because they reflect more than 99.9 percent of the incoming sunlight at all wavelengths, are perfectly safe *as long as they are secured to the front of your telescope.* If necessary, tape the filter to your instrument. A good wind can easily dislodge an over-the-aperture filter if it is not properly fixed to the tube.

Under no circumstances remove the filter while the telescope is pointed at the Sun. An annular eclipse is not the same as a total eclipse, and the Sun's disk is never completely blocked. At maximum



MARS AND URANUS lie in the same 1.0° field of view on January 29. Their positions are shown at 7 a.m EST (6 a.m CST, 5 a.m MST, and 4 a.m PST) and south appears at top, to match the view in an inverting telescope.

eclipse, the bright ring of sunlight rimming the darkened Moon is still intense enough to permanently damage your eyes or blind you before you can blink.

Unfortunately, observers will not see the compelling prominences, rosy chromosphere, or pearly coronal features visible during a total eclipse. The annulus of sunlight is too dazzling. Still, a small telescope or short focal-length telephoto lens can easily show you sunspots during the partial phases, even when the Sun is low in the sky. Enjoy this eclipse for what it is, not for what it isn't.

FIND A PROTOSTAR

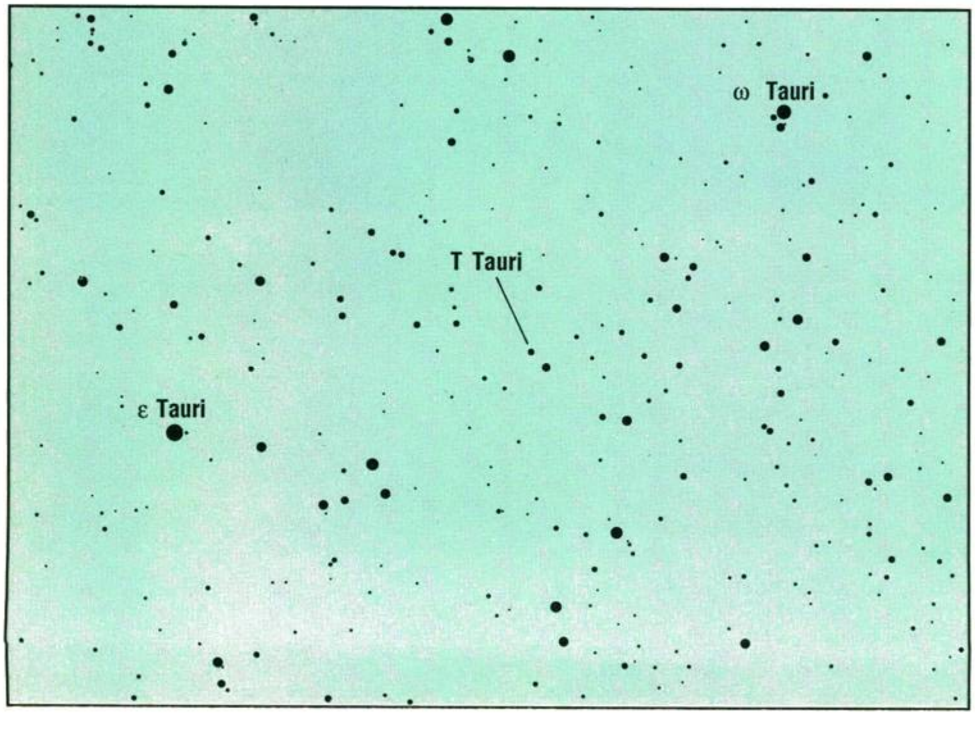
The region in and around Taurus the Bull is rich in star-forming regions. One of the more interesting of these is Hind's Variable Nebula, which, as its name implies, fluctuates occasionally in brightness. Although you need at least a 12-inch telescope to detect this faint reflection nebula, smaller telescopes easily show the object responsible for its brightness fluctuations, a variable star known as T Tauri.

Although it is classified a variable star — and is the archetype for other objects of similar nature — T Tauri is not yet a star, but a protostar. It has collapsed from its cocoon of dust and gas and is in the initial stages of nuclear reactions.

T Tauri lies midway and just northeast of a line between Delta^1 (61) and Omega Tauri. If you have a good set of setting circles and a polar-aligned mount, you can pinpoint the T Tauri region by first centering your field of view 1' west of Delta^1. Then, without changing right ascension, slew northward in declination exactly 2°. T Tauri is the more northern star of a pair that should be near the center of your field of view.

T Tauri's brightness varies irregularly from magnitude 9 to about 13.5, though most variable-star observers report that it rarely fades below magnitude 10.6. The finder chart below will help you locate this star-to-be. Perhaps you will catch it winking at you.

THE PROTOTYPE OF PROTOSTARS is T Tauri, a star just beginning to ignite the fires of nuclear fusion. You can starhop to this protostar from either ε Tauri — the northernmost star in the "V" of Taurus — or ω Tauri. North is at top in this view of the T Tauri field.



TELESCOPIC PLANETS

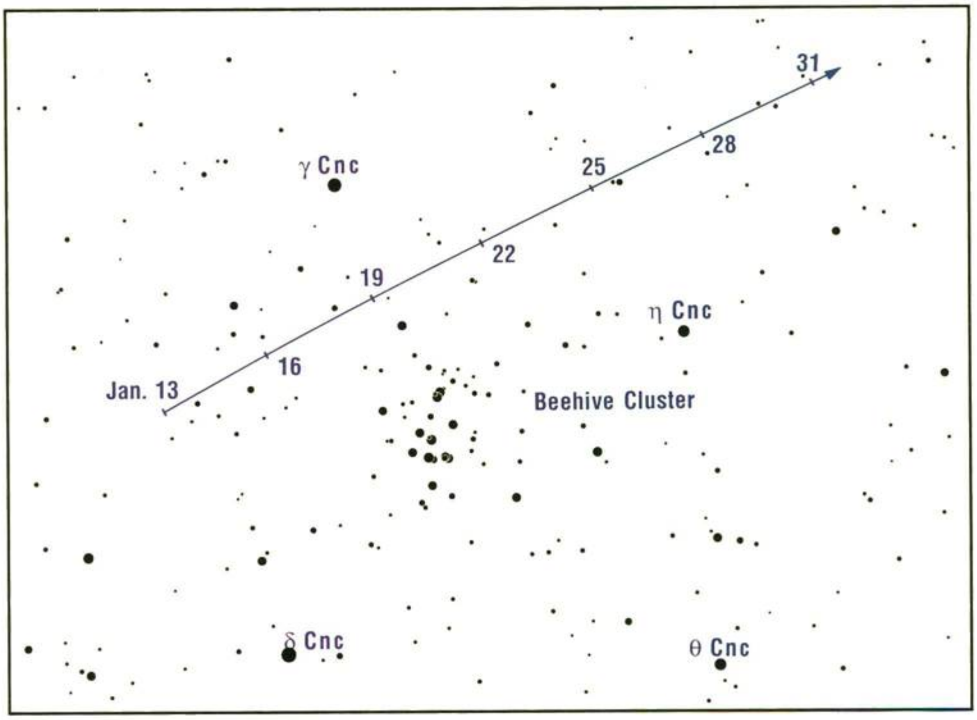
As January opens, Saturn can be found in Capricornus, which now lies very low in the southwest after sunset. The ringed planet shines at magnitude 0.7 and its rings span 35". If you want to observe Saturn, you'd best not delay. The planet is moving toward solar conjunction on January 29 and by mid-month is lost in the Sun's glare.

The morning sky is where you'll find most of the planetary action this month. On the 10th, look for Mercury and Mars very low in the east around 6:45 a.m. local time, when they appear less than 1° apart. They lie only 5° above the horizon at sunrise, however, so you may have difficulty spotting the pair.

Mars is the fainter and smaller of the two planets. Glimmering at magnitude 1.7, the Red Planet is still so far from Earth that its disk is no more than 3.9" in apparent equatorial diameter. Mercury, meanwhile, appears at magnitude –0.4 and has a 5.6"-diameter disk that is 85-percent lit.

As Mars climbs higher in the sky, it has another interesting conjunction when it passes 0.4° south of Uranus on January 29. The Red Planet still shines at magnitude 1.4, though its apparent diameter has grown slightly to 4.1". Uranus, on the other hand, has a pale blue-green disk that measures 3.4" across and shines at magnitude 5.8.

Jupiter, too, is still in the morning sky, appearing high overhead at sunrise. But it now rises well before midnight and can be seen low in the east during the late evening. The –2.3-magnitude planet sports a 41.8"-diameter disk at midmonth. Jupiter reaches opposition next month, when it appears biggest and brightest and makes the transition into the evening sky.



FLORA SKIRTS THE EDGE of the famous Beehive star cluster during the second half of January, making the 9th-magnitude asteroid relatively easy to locate. Positions are shown for 11 p.m. EST (10 p.m. CST, 9 p.m. MST, and 8 p.m. PST).

COORDINATES FOR FLORA

Date	R.A. (2000)	Dec.
Jan. 13	8h48.4m	19°55'
Jan. 16	8h45.3m	20°19'
Jan. 19	8h42.1m	20°43'
Jan. 22	8h38.8m	21°06'
Jan. 25	8h35.4m	21°29'
Jan. 28	8h32.0m	21°51'
Jan. 31	8h28.7m	22°13'

THREE ASTEROIDS AT OPPOSITION

Observers who relish scouring the sky for minor planets will be happy to learn that three such bodies come to opposition this month. The first is 29 Amphitrite on January 3. Amphitrite lies about 1° south-southeast of 4th-magnitude Theta Geminorum, near the outer fringes of the Milky Way. A number of 9th-magnitude stars are in the area, which makes identifying the 8.9-magnitude point of light a challenge.

To locate Amphitrite, or any asteroid for that matter, you need to detect its movement among the stars. You do this by first selecting an eyepiece that "confines the field," i.e., zeros in on the region in which the asteroid is located. An eyepiece with a true field of slightly over 1° is a good starting point, enabling you to compare stars plotted on atlases like *Uranometria 2000.0* to the positions of real stars in select areas, and thereby pinpoint your target. The object is to narrow down your search area, though not so far that you lose your pilot stars.

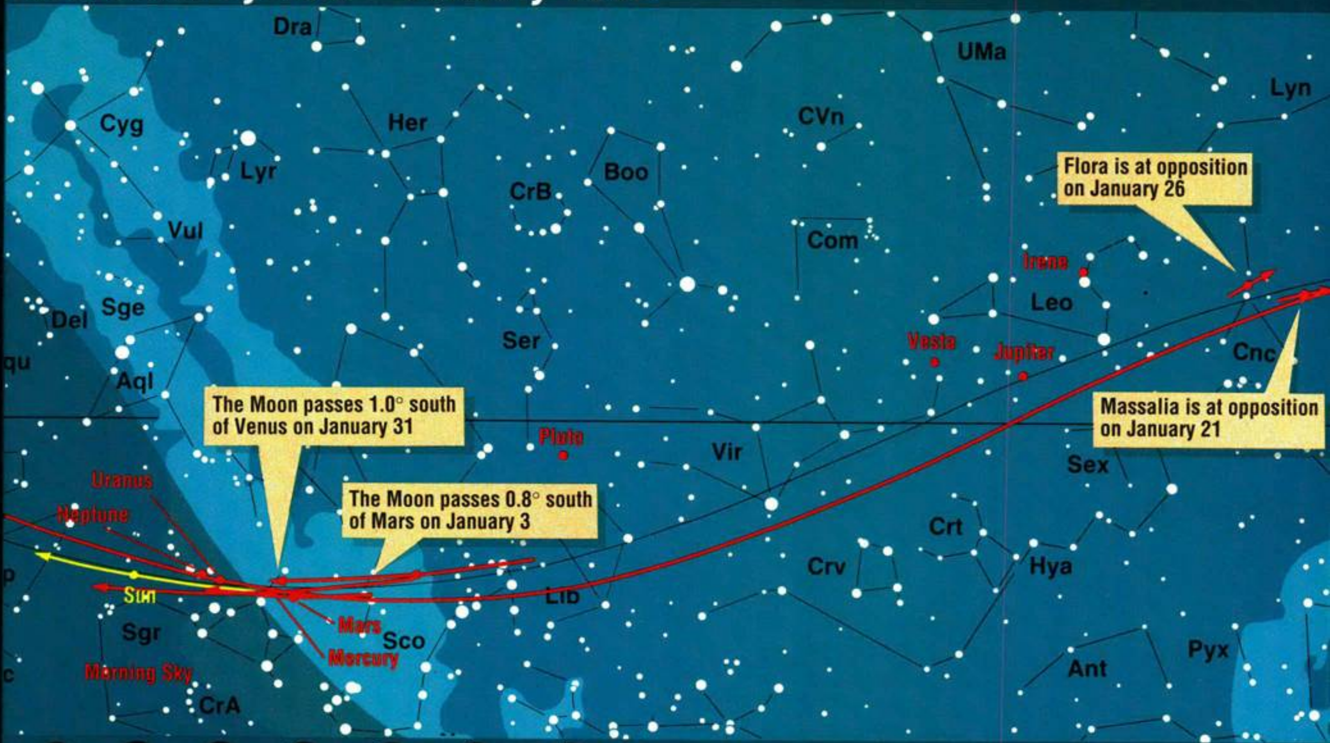
Once you're on top of the search area, carefully sketch all the stars you see with respect to each other. The next night compare your chart to the same field. The "star" that has moved is your asteroid.

The second asteroid to come to opposition is 20 Massalia, on January 21. At magnitude 8.5, it is the brightest of the three, and it lies in a sparse region of Cancer. Look a little over 1° northwest of Zeta Cancri for a tiny square of 9th-magnitude stars just southeast of a bright 6th-magnitude star — all within a 1°-wide field of view. Massalia will be in there somewhere, a little brighter than the foursome.

Finally, on January 26, 8 Flora reaches opposition not far from Massalia's former location. On that evening, the 8.7-magnitude asteroid lies only 1° northwest of the Beehive cluster, with Eta Cancri to the south and Gamma to the east. The finder chart and table of coordinates above will help get you to the right area. ☐

A former associate editor of ASTRONOMY, Jeff Kanipe is the editor of Star Date *magazine, which is published by McDonald Observatory at the University of Texas at Austin.*

The Solar System January 1992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Lib
Sgr
Mars
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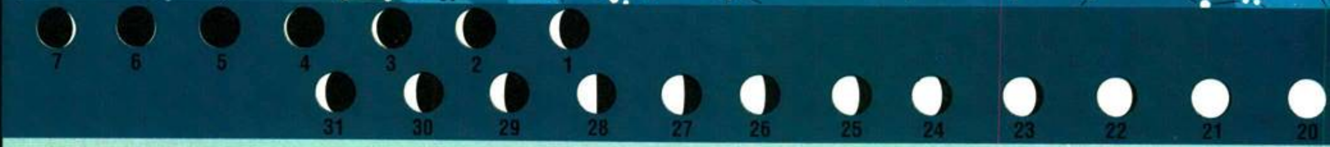
Mercury
Pyx
Morning Sky
Ant
CrA

Flora is at opposition on January 26

Massalia is at opposition on January 21

The Moon passes 1.0° south of Venus on January 31

The Moon passes 0.8° south of Mars on January 3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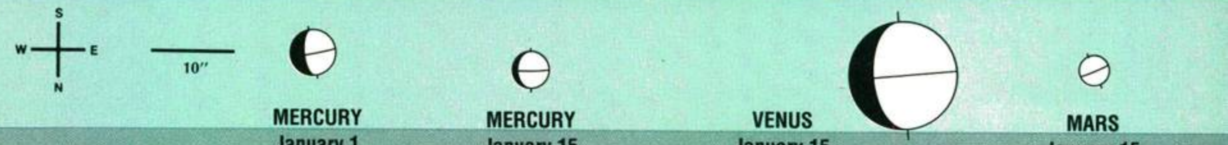
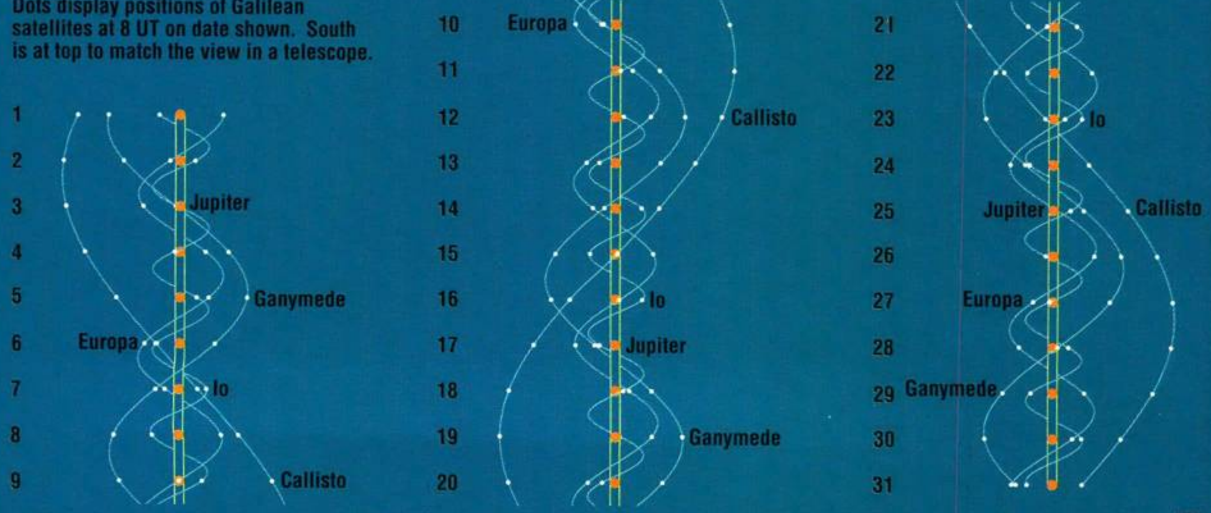
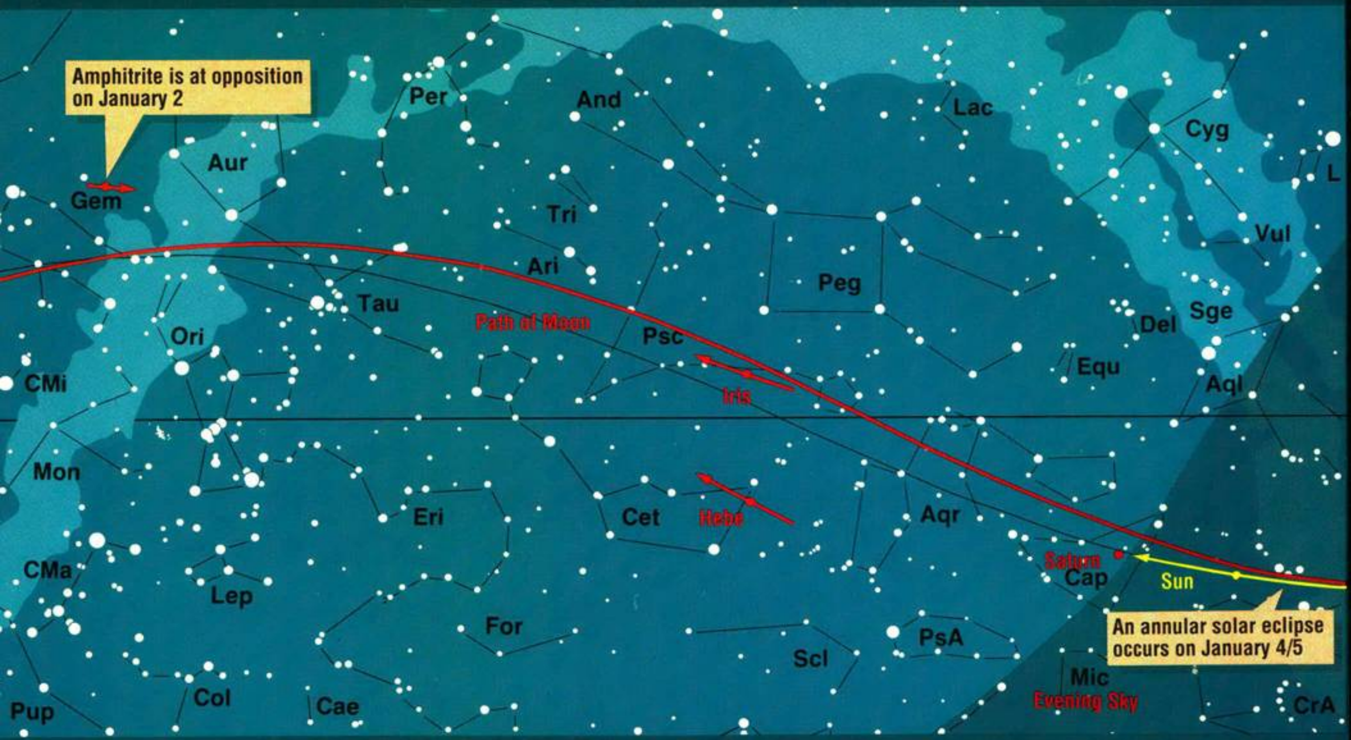


Planet	MERCURY	MERCURY	VENUS	MARS
Date	January 1	January 15	January 15	January 15
Magnitude	−0.3	−0.4	−4.0	+1.4
Angular Size	6.1"	5.2"	13.8"	4.0"
Illumination	73%	89%	79%	99%
Distance (AU) from Earth	1.098	1.330	1.207	2.361
Distance (AU) from Sun	0.409	0.460	0.722	1.474
Right Ascension (2000.0)	17h09.1m	18h31.4m	17h06.4m	18h18.7m
Declination (2000.0)	−21°29'	−23°41'	−21°13'	−23°59'

Jupiter's Moons

Dots display positions of Galilean satellites at 8 UT on date shown. South is at top to match the view in a telescope.

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Cap
Sun
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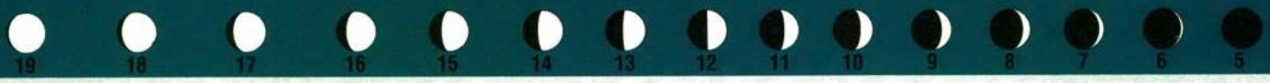
Mic
Evening Sky
CrA
Pup
Col
Cae

Amphitrite is at opposition on January 2

An annular solar eclipse occurs on January 4/5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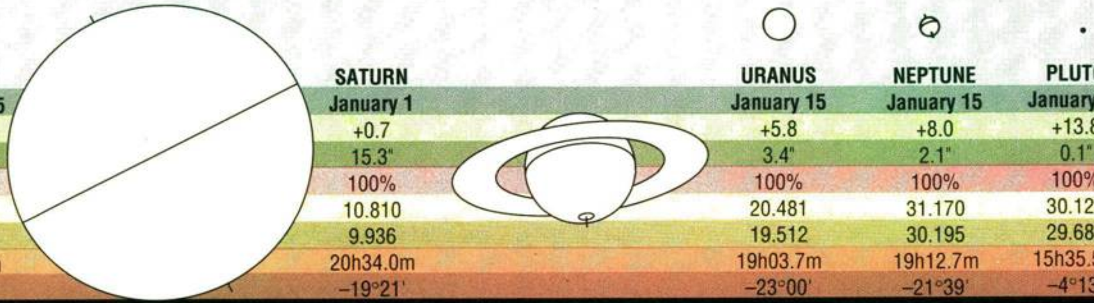
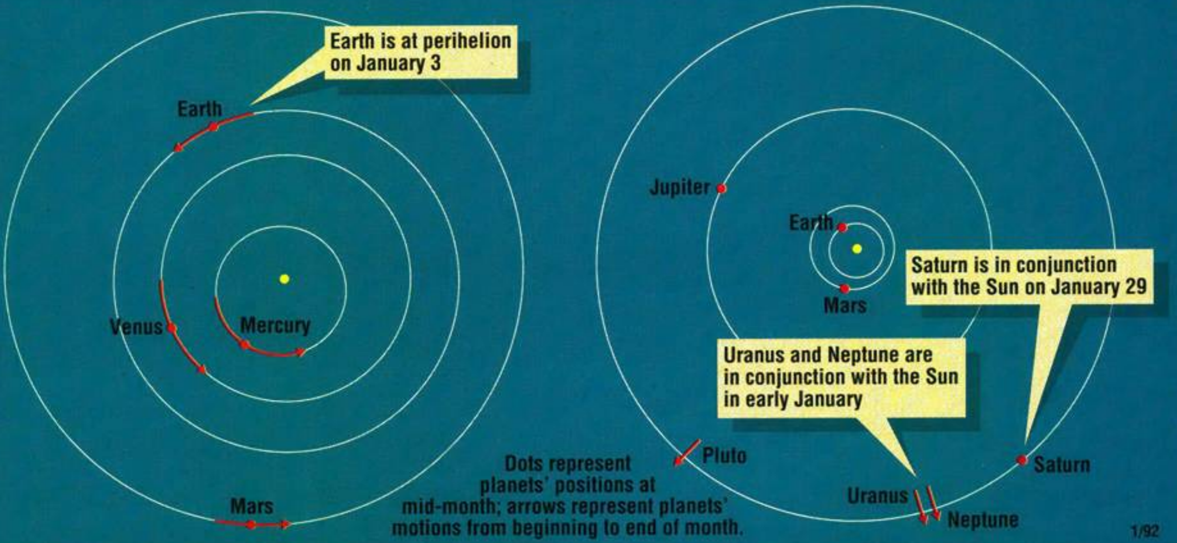


JUPITER January 15	SATURN January 1	URANUS January 15	NEPTUNE January 15	PLUTO January 15
−2.3	+0.7	+5.8	+8.0	+13.8
41.8"	15.3"	3.4"	2.1"	0.1"
100%	100%	100%	100%	100%
4.709	10.810	20.481	31.170	30.128
5.392	9.936	19.512	30.195	29.688
11h04.3m	20h34.0m	19h03.7m	19h12.7m	15h35.5m
7°18'	−19°21'	−23°00'	−21°39'	−4°13'

The Planets in Their Orbits


Earth
Venus
Mercury
Mars
Jupiter
Earth
Mars
Pluto
Uranus
Neptune
Saturn

Earth is at perihelion on January 3

Saturn is in conjunction with the Sun on January 29

Uranus and Neptune are in conjunction with the Sun in early January

Dots represent planets' positions at mid-month; arrows represent planets' motions from beginning to end of month.

AN EYE ON THE DEEP SKY

You can see a treasure-trove of galaxies, clusters, and nebulae with just your naked eye.

by Alister Ling

I'll let you in on a big secret — you don't need a telescope to explore the wonders of deep space. All you have to do is lie back, cradle your star charts, and look up. Humans have watched the stars wheel overhead for thousands of years, but they did not understand what the tiny lights signified. With your knowledge of the sky's wonders, your eyes can bring you an observing experience that is both enjoyable and precious.

If you own a big telescope, you may be thinking "Hah! Why should I use just my eyes?" Well, remember the thrill you got when you first saw the Crab Nebula? It was quite a kick detecting the tattered remains of an exploded star, even if you couldn't make out any details. Naked-eye observing of deep-sky objects can bring you that same feeling, if you just open your mind.

You can see over 40 deep-sky objects without a telescope, and a handful of those are visible even from the city. You can identify galaxies, gas and dust clouds, variable stars, and star clusters. That's a lot of wonderful sights to feast your eyes on.

Prepare for your night of naked-eye observing as you would for any other. You'll certainly want the creature comforts — warm clothes (with a blanket or sleeping bag), a thermos for a hot drink, and the standard red flashlight and star charts. Also bring along a pencil and paper to take notes of what you see. Don't forget to jot down the names of any friends you're observing with and any emotions you feel. Years from now those words will make the evening come back to life with incredible clarity.

Piercing the City Lights

As you'd expect, the best view of the sky comes from dark rural areas, where the Milky Way's beauty is beyond compare. But there's still a lot to see from the city. The most accessible deep-sky object is the Pleiades star cluster. Its tiny dipper shape is easy to pick out on these chilly winter evenings.

Don't let yourself get caught up in competitions based on how many Pleiads you can count with your naked eye. Just enjoy the view. If you can see five or more stars, you're doing fine. However, if all you see is a misty blur, give yourself a present — glasses for distance vision. You'll see hundreds of sharp, sparkling stars across the entire sky that you can't see now, a sight that will give you more pleasure than you can imagine.

More than 40 deep-sky objects can be seen without a telescope.

Just a few degrees south of the Pleiades lies another star cluster, the Hyades. Ruddy Aldebaran appears to be the brightest member of this stellar grouping, but in fact it is a foreground star. Most clusters have roughly the same physical size, so the larger a cluster appears, the closer it usually lies. The Hyades appears bigger than the Pleiades because it is only 150 light-years away compared with 400 light-years for the Pleiades.

Searching for Faint Fuzzies

From mid-northern latitudes, only one gas cloud, or nebula, is bright enough to pierce through the light pollution. That's the Great Orion Nebula, or M42. From the suburbs, M42 can be spotted as the fuzzy middle star of Orion's Sword, which hangs down from the three belt stars.

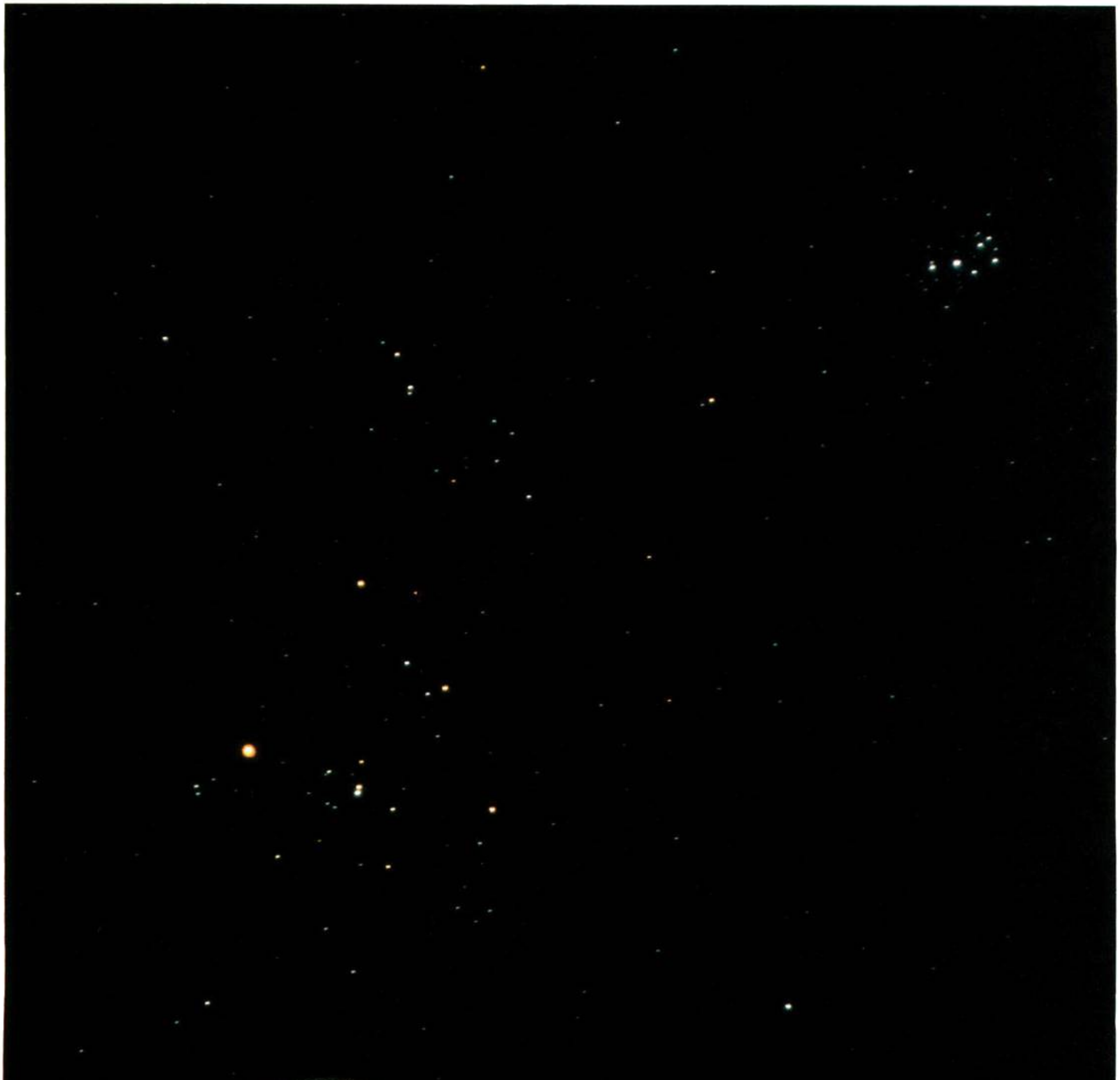
While you gaze intently at the sword region, take some time to appreciate its setting. The stars of the belt and all of the luminous winter stars — Sirius, Rigel, Betelgeuse, Capella, and the others — form a huge celestial "G." Because of our atmosphere's turbulence, these diamonds dazzle and sparkle in a beautiful way that's impossible to capture on film. As lovely as they are, wide-angle photographs of the region just can't measure up to "being there" in person.

As good as M42 is, it can't compete with the Eta Carinae Nebula. Eta Carinae's high surface brightness is enough to easily pierce the light pollution veil of an urban metropolis. Unfortunately for those of us in the north, that metropolis needs to be near or below the equator, because Eta Carinae lies deep in the southern sky.

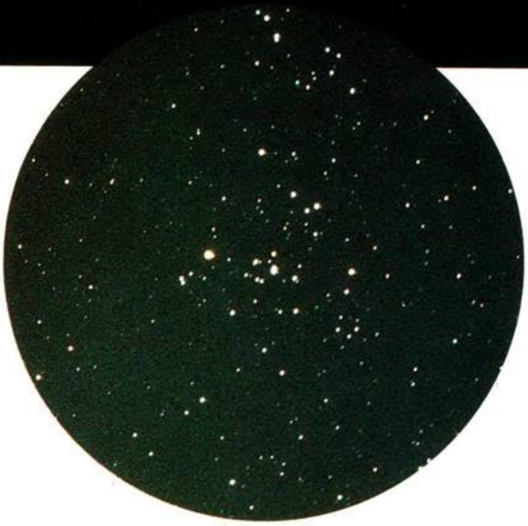
If you're a beginner or the sky conditions are poor, you may see these celestial wonders only as faint stars. Don't get discouraged. Try shading your eyes and letting them adjust to the darkness a bit more. Patience will reward you.

You can also use your naked-eye skills to follow the brightness changes of some of the brighter variable stars. Variables can be fascinating to watch. Some, like Algol in Perseus, vary in brightness because they are eclipsed by a less-luminous companion. Algol normally shines at magnitude 2.1,

ORION'S STANDOUT deep-sky attraction is the Orion Nebula, which appears to the naked eye as a fuzzy patch of light in the middle of Orion's sword. Photo by Jim Curry.



TAURUS IS HOME to two naked-eye star clusters — the dipper-shaped Pleiades and the V-shaped Hyades. Photo by Jeffrey Prince and Harry Klee.



YOU CAN SEE SEE A DOZEN or more stars in the Hyades cluster with just your naked eye. However the brightest star in this region — ruddy Aldebaran — is a foreground star. Photo by Ralph Heiden.

THE BEST DEEP-SKY OBJECT for naked-eye observers is the Pleiades, a stunning stellar cluster that lies high in the south on winter evenings. Photo by Richard Hammar.

but during a 10-hour period it fades 1.3 magnitudes and then returns to normal. Then, 2.9 days later, it fades again. If you start an observing session when Algol is at its minimum, you will see it recover most of its brightness in only 4 hours. Watching Algol vary, by comparing its brightness to Alpha Persei or Gamma Andromedae, makes for a fascinating winter or fall project. The trick is that Algol is often at minimum brightness during the day or late at night, so it might take you a number of tries to catch it in its fading act. You can find the times of Algol's minimum brightness in the Royal Astronomical Society of Canada's *Observer's Handbook*.

Beta Lyrae, which is an eclipsing binary in the summer sky, is easier to catch at minimum than Algol. At normal brightness it is almost equal to Gamma Lyrae, and every 13 days it fades 1.0 magnitude for a whole night. You can test your sharpening observing skill on Beta Lyrae by looking for its secondary minimum. Two nights after it returns to full light following its prominent minimum, it slips 0.3 magnitude for another night.

To see a star that varies intrinsically in brightness, we have to wait until late summer and fall. Mira, in the constellation Cetus the Whale, is the sky's best slowly varying red giant. Mira climbs from invisibility (at 9th magnitude) to 4th magnitude and then fades again roughly every 330 days. This is definitely a leisurely project! Expect Mira to peak in July this year, though keep in mind that it is not totally predictable and its peak brightness and period vary somewhat from one cycle to the next.

Once you've seen one of these variables fade and recover, you'll have a friend for life in the sky, beckoning you to check up on it on any night. Even if you're not a variable star observer, you can still get a kick from watching the antics of these stars.

Reveling under Dark Skies

The universe really opens up to inquisitive eyes when the sky is free from light pollution. All of the objects that can be spotted from the city become obvious out in the country. For maximum effect, remember to use averted vision. That's the technique where you look to the side of the object you're examining so the faint light falls on the more sensitive part of your eye's retina.

Don't miss the Double Cluster, a striking pair of clusters visible from more than 7,000 light-years away.

From the Northern Hemisphere, the rural observer can add ten open clusters to his or her list, in addition to the Pleiades and Hyades. A prime example is the nearby group of stars in Coma Berenices. Wistfully known as the "Hair of Berenice," this springtime cluster (catalogued as Melotte 111) lies only 260 light-years away and measures almost 5° across. Although only eight stars are readily visible (the three brightest are not group members), there are a number right at the eye's limit that seem to flicker in and out of view. There is an undeniable charm here that people have been trying to capture in words for over two thousand years. Phrases like "gossamer spangled with dewdrops" only begin to hint at the elegant beauty of this object.

Once we look farther out into our Galaxy, our unaided eyes can no longer distinguish individual stars in a cluster, but the light of dozens or hundreds of faint stars can be seen as a misty patch or glow. The most prominent of these is the Beehive Cluster (M44) in Cancer, located about 500 light-years away. A bit farther out (800 light-years) is M7, tucked in among the Sagittarius-Scorpius starfields. The slightest optical aid resolves both of these clusters into stars.

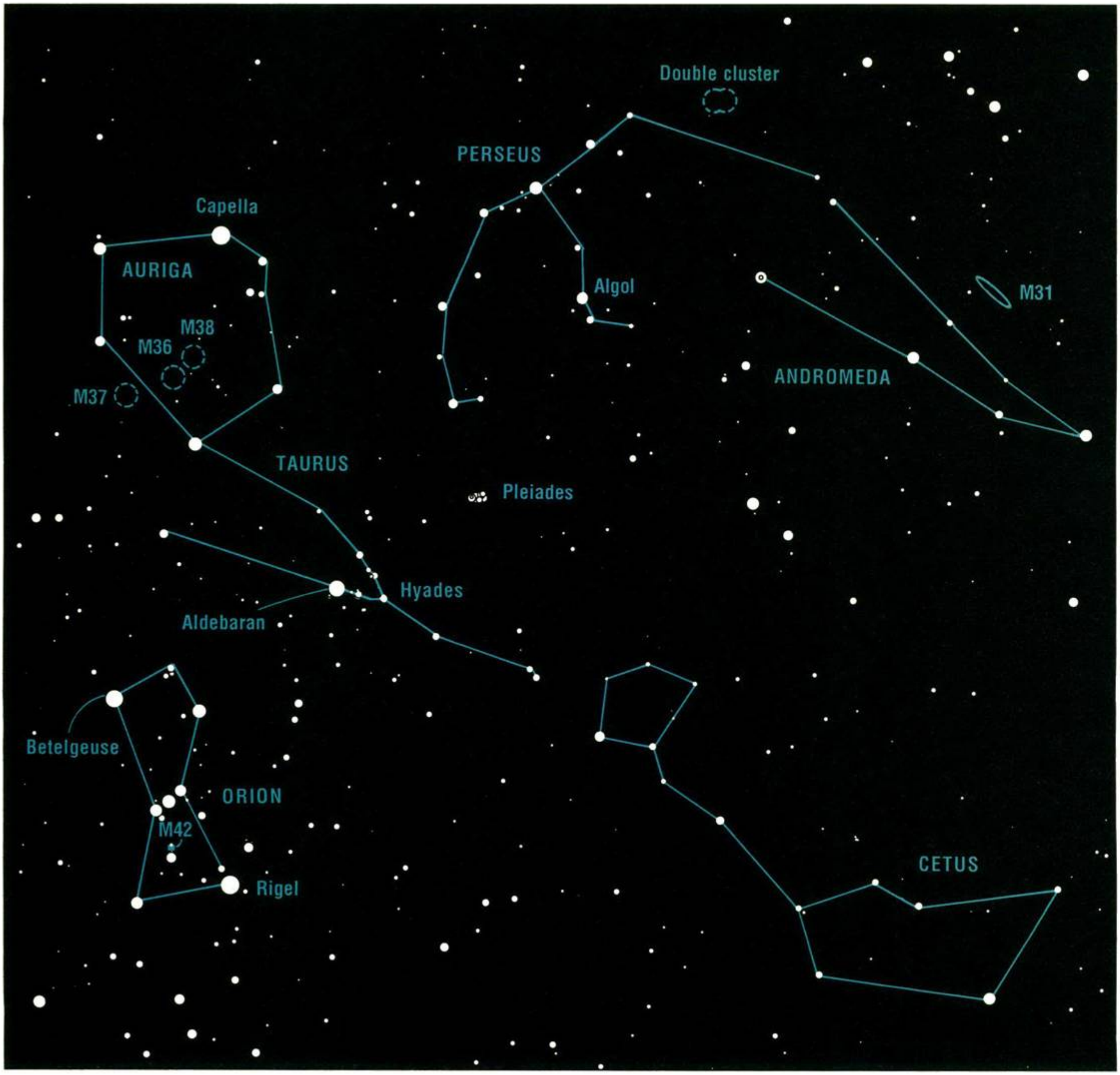
As our gaze penetrates past 1,300 light-years from Earth, we can see the 1° cloud NGC 752 south of Gamma Andromedae and the smaller M34 to Gamma's east. But from this point on, the increasing distance causes the nebulous spots to appear smaller — M6, M35, and M41 are more than 600 light-years farther still and roughly half the apparent size of NGC 752.

One object outstanding in many ways is the Double Cluster in Perseus. Despite a vast distance of over 7,000 light-years, these two clusters' numerous bright suns blaze across the void, making them among the easiest of deep-sky objects from the country. The soft double knot in the Milky Way stands out just southeast of Cassiopeia, even with interference from twilight or mild light pollution. Can you tell which of the clusters is brighter?

If you wish to pursue more open clusters, try other Messier clusters, especially the three in Auriga. A good source for information on clusters is *Sky Catalogue 2000.0*.

Clusters of a Globular Kind

Globular star clusters are massive conglomerations of hundreds



of thousands of stars that are distributed in a spherical halo about our Galaxy. The brightest globulars are just visible to the naked eye.

The most obvious one is Omega Centauri — so bright that it was first catalogued as a star. It appears as a 4th-magnitude fuzzball in the southern constellation Centaurus. Not far behind Omega is 47 Tucanae, which lies even deeper in the southern sky.

It's unfortunate that the two brightest globular clusters in the sky are always below the horizon for observers at mid-northern latitudes, but there are still a few visible from the Northern Hemisphere. The two best are M22 in Sagittarius and M13 in Hercules — at distances of 10,000 and 23,000 light-years respectively. In fact, once you know exactly where to look, you'll be able to find them routinely.

The best telescopic and photographic gas clouds, by virtue of being the biggest and brightest in the sky, are the easiest to spot with the naked eye. The two brightest are the Orion and Eta Carinae nebulae, which are at their best this time of year. To see any others, you'll need to wait for summer and choose a dark-sky observing site. The best summertime nebula is M8, the Lagoon, in Sagittarius. It is quite large, appearing like a detached part of the Milky Way. As you reach darker and darker skies, keep on the lookout for the other summer-sky favorites, such as M17 the Swan, M16 the Eagle, and high overhead the North America Nebula in Cygnus. Ask yourself whether you are seeing the North America Nebula itself or its edge brought into sharp relief by the dark nebula that forms the eastern "coastline of the continent."

If you own a light pollution or nebular filter, you can expand your

FROM THE ORION NEBULA to the Andromeda Galaxy, winter's evening sky holds the greatest collection of deep-sky objects for the naked eye.

FOR GALAXY OBSERVING, southern observers can't beat the Large Magellanic Cloud. This satellite galaxy to the Milky Way contains a wealth of internal detail for the naked eye. Photo by Hans Vehrenberg.

repertoire of gas clouds. Because these filters have a shiny surface that reflects a lot of stray light, rig up a little sighting tube by cutting out the back of a black film canister and securing the filter in place. Bring along your star atlas because you never know what you may find. Among the tougher targets are the California Nebula in Perseus and Barnard's Loop in Orion, but the North America Nebula is easy!

A Trip out of the Galaxy

A dark sky allows you to make an incredible leap outward into the universe. Our neighbor galaxy M31 is over 2 million light-years away. It is also bright enough to be spotted from suburbia, late at night after the locals have turned off their lights.

Here too, you can experiment with the sky's transparency and your averted vision — the bright central area is elongated about a degree or so, but with patience you will be rewarded by the sight of the faint outer halo spanning 3.5°. In the darker skies of old, some people claimed to have seen as much as 5° of galaxy!

If you live in the Southern Hemisphere, or merely plan to travel there, be sure to observe the superb Magellanic Clouds. These two satellite galaxies of the Milky Way offer a number of internal details to the naked-eye observer. Perhaps most impressive is NGC 2070, the Tarantula Nebula, located in the Large Magellanic Cloud. This cloud of gas and dust is so large and bright that if it replaced the Orion Nebula, it would span 30° and shine more than a magnitude brighter than Venus!

The Pinwheel Galaxy (M33) in Triangulum makes a good test of sky conditions. On dark nights the 1.5° oval is unmistakable once you know where to look. In poorer skies the search for M33 can frustrate even the experienced observer. Unfortunately, this galaxy is featureless to the naked eye.

That's it for galaxies — or is it? Let's not forget our own Milky Way! On summer nights the brighter sections of the Milky Way span from horizon to horizon arching high overhead. Because we're inside this Galaxy, we tend to forget that in effect we are looking at one huge edge-on galaxy!

If LMC's Tarantula Nebula were as close as the Orion Nebula, it would span 30° and shine brighter than Venus.

For the naked-eye Milky Way observer, it is the dark nebulae that command great interest. The amount of detail visible along the mottled band can often give you a better feel for the general sky conditions than just a simple limiting magnitude estimate. A truly dark sky will reveal an unbelievable intricacy of obscuring matter in our Galaxy.

You can start dark-nebula hunting with the principal features of the Milky Way. Then, as you become familiar with their layout, you can seek the smaller and more subtle dark lanes and figures. Or you can simply let your eyes take you where they may, darting from one area to the next.

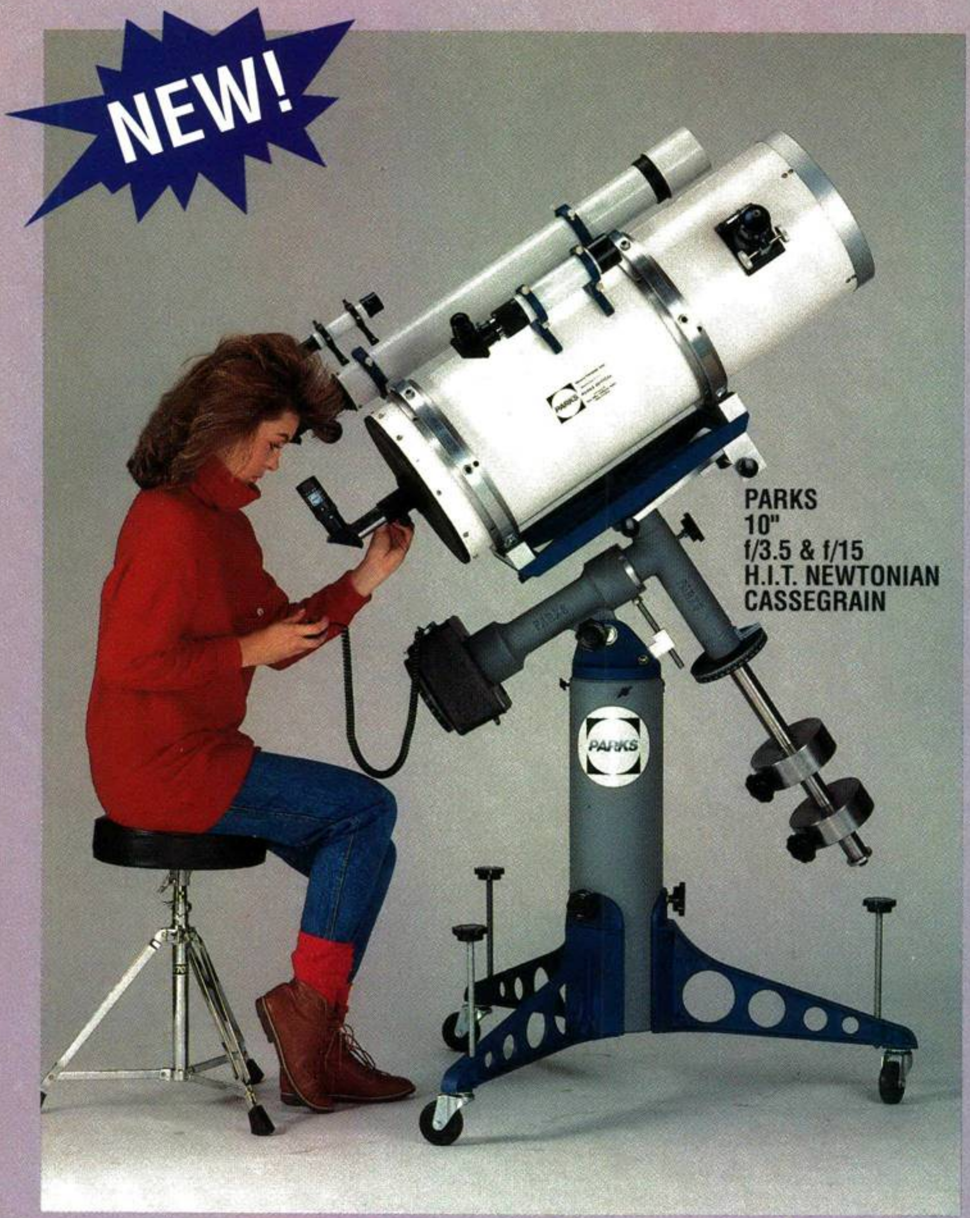
The most noticeable dark feature in the northern sky is the Great Rift, which cuts from Cygnus heading southward. The Scutum Starcloud stands out because it is surrounded by this dark nebula. A visual prize on really dark nights is the Dark Horse Nebula in the Sagittarius-Ophiuchus region (visible in the photographs at the top of page 80).

It is in this realm of Milky Way observing that a photograph cannot do justice to the view. Sure, I can appreciate a well-composed picture that reveals objects my eyes cannot see, or I can ooh and aah at a fisheye shot of the entire sky. But neither of these can substitute for reality — the wonderful emotions that envelop me when I stand on a mountain and experience the grand expanse of our Galaxy for myself.

Whether you are a newcomer to observing or a full-fledged expert in the field, find some time to cast your eyes upward and explore the wonder of the naked-eye sky. Something new will catch your fancy — a variable star, a subtle band of obscuring dust, a distant cluster of stars. Leave behind the fast pace of life and return to nature. Finally, treat yourself to the colorful glory of a morning twilight breaking into sunrise. Naked-eye observing will make you feel real good. ☐

Alister Ling is a meteorologist with Environment Canada and a columnist for ASTRONOMY's sister publication Deep Sky. *Night or day, he is a watcher of the skies.*

Parks: The More You Lo



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From left to right: PRT-1, PRT-2, PRT-46

PRT-813

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The PRT Refractor series features quality construction with a high performance 1¼" viewing system. Department store-type telescopes usually use the .96" eyepieces, which have smaller fields of view and inferior image quality. Parks Refractors uses sturdy metal optical tubes and fully coated achromatic objective lenses. Add a camera adapter and a t-ring and you have a powerful telephoto lens. Each PRT includes a 25mm multi-coated 1¼" Kellner eyepiece, a diagonal prism for a right-side up view, a sturdy adjustable wooden tripod, finderscope and a lifetime warranty.

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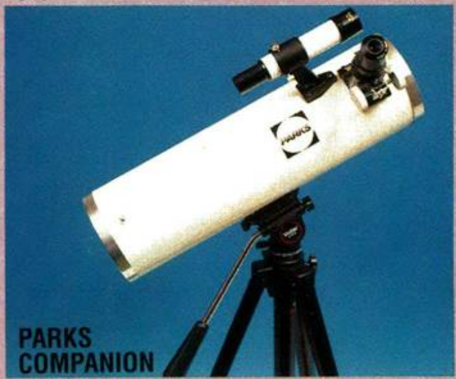

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Give Your Camera a Piggyback Ride

Piggyback photography can create star-filled astrophotos that will knock your socks off. A pro tells you how.

By John Sanford

Going piggyback is a great way to get first-class astrophotos with relatively little effort. It is an ideal technique for anyone starting out in astrophotography. The procedure is simple: you attach a camera to the top or side of a telescope that has an equatorial mount (or perhaps just to an equatorial mount on its own). The mount should have a motor to drive the scope, and with it the camera and its lens, across the sky to follow the stars. A typical exposure time with the camera lens set to f/2 or f/2.8 might be 5 to 30 minutes. The result is a photograph that records stars as pinpoints and picks up stars and nebulosity far fainter than you can see with the unaided eye.

Using a wide-angle lens, a normal 50mm lens, or telephotos under 500mm, it is possible to frame complete constellations, Milky Way star fields, large star clusters such as the Pleiades, bright comets, patches of nebulosity, the Andromeda Galaxy — the list goes on. There are enough large and beautiful deep-sky targets to keep you occupied for years doing nothing but piggyback photography.

Fine-Tuning the Equipment

If you have an equatorial mount and a camera, you can do piggyback photography. But ensuring the best results requires attention to detail. The critical first step is to mount the camera securely to the telescope or equatorial mount. You don't want the camera to shift or sag during the exposure.

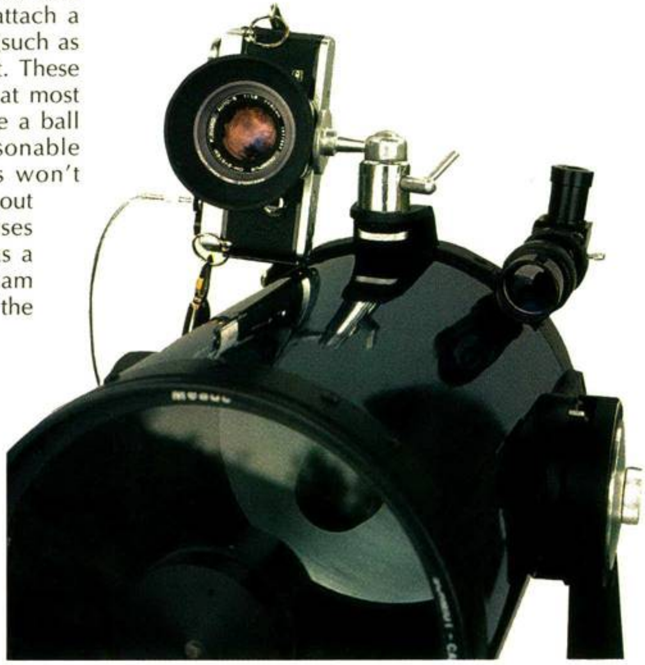
With Schmidt-Cassegrain telescopes, it's easy — they have accessory piggyback brackets that bolt to the side of the tube. For small refractors and reflectors, Meade and Celestron make accessory rings that clamp around the tube.

Telescopes on German equatorial mounts often feature a ¼-20 threaded hole in one of the tube rings. To use this, screw in a long ¼–20 bolt and hacksaw it off above the hole, leaving about 4 or 5 threads above the plane of the ring. After filing the end smooth, thread on a nut to hold the bolt in place. Some mounts come with a ¼–20 threaded bolt already in place.

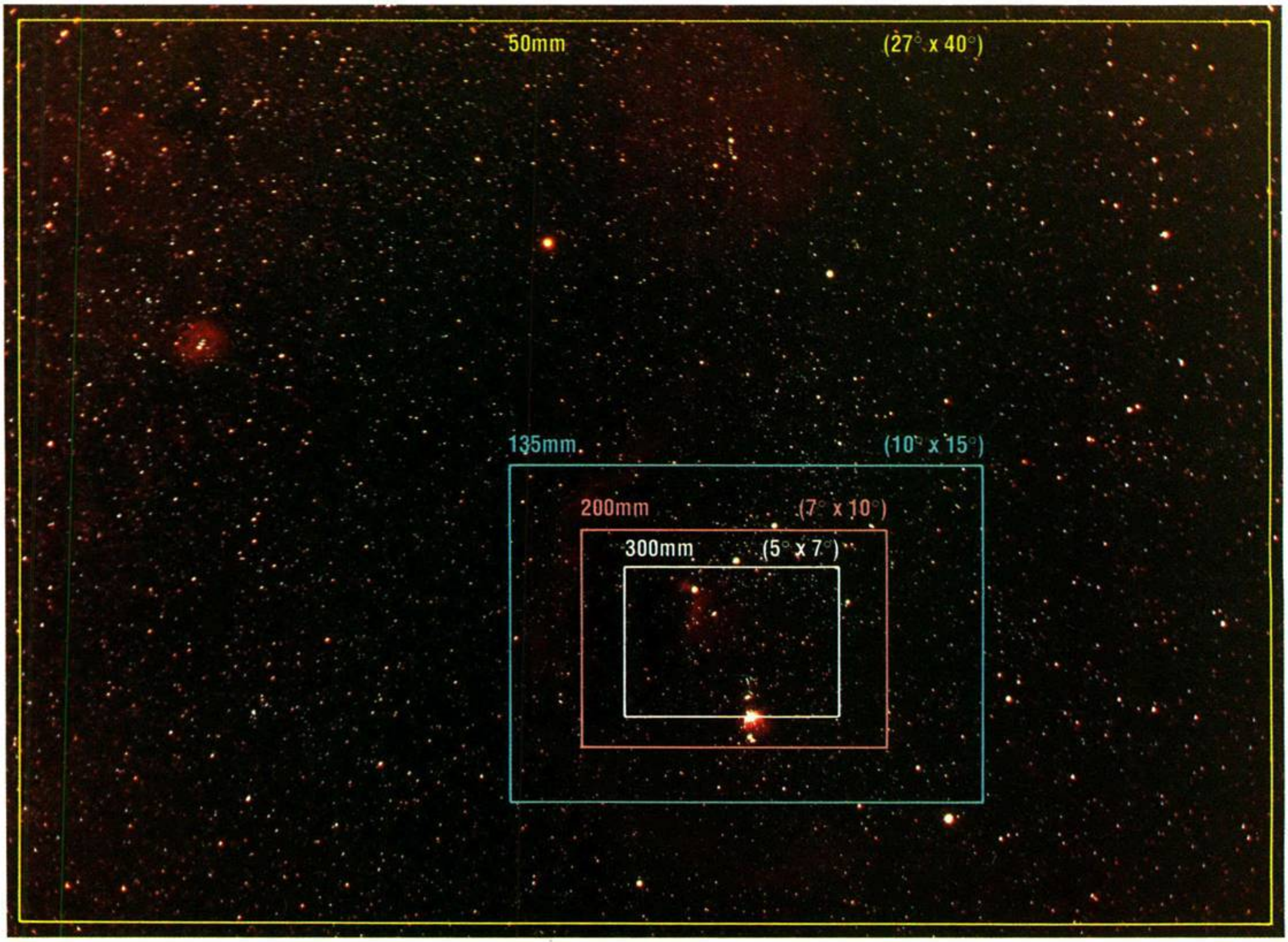
In either case, you could attach a camera directly to the ¼–20 bolt but a better method is to attach a "ball head" camera mount (such as the one at right) to the bolt. These tripod heads are available at most camera stores. Find as large a ball head as you can at a reasonable price — the smaller ones won't hold a heavy telephoto without sagging. Even so, long lenses may need a support such as a wooden block or dense foam block set under the front of the lens.

The ball head does two things: it allows the camera to point in any direction independently of the telescope to frame areas of the sky as you want, and it allows the camera's field of view to clear the front of the telescope by pointing above the barrel of the scope. Having the scope in the camera's field of view can be a problem when using wide-angle lenses, even on stubby-tubed telescopes like Schmidt-Cassegrains. For example, when I shoot with a 15mm lens I have to point the lens almost at right angles to the telescope in order to get the tube out of the frame!

The bigger the telescope, the larger the lens you can attach. An 8-inch Schmidt-Cassegrain can take up to a 500mm lens before the load causes flexure problems. But even with smaller lenses, plan to add counterweights to the tube or mount to help balance the telescope. For most clock drives to work properly, the telescope needs to be balanced evenly around the right ascension axis (the east-west motion). In declination (the north-south motion) you can tolerate a little imbalance, provided you can firmly lock the declination axis.



A 15MM ULTRA-WIDE ANGLE lens recorded a panorama of the summer Milky Way from Cygnus (at top) to northern Sagittarius. The camera and lens were piggybacked on a telescope (similar to the setup shown at right) to track the stars during this 10-minute exposure on Ektapress 1600 print film. Photo by the author.



A NORMAL 50mm LENS nicely frames the nebulosities of Orion (above). Chris Schur used a 60-minute exposure at f/2.8 on hypered Fujichrome 100 film with a Deep-Sky filter. Zooming in on selected objects requires the narrow field of a telephoto lens. For example, to frame the region of the Orion Nebula (below), Lill Nelson used a 280mm telephoto set at f/2.8 and a 20-minute exposure on hypered Ektachrome 200 film.

The next step is precise polar alignment. Piggyback picture taking can require little or no manual guiding during the exposure because the clock drive does all the work. This is possible with lenses under 200mm focal length, but only if the drive has no appreciable periodic error in the right ascension gear train and if the setup has been perfectly aligned with the celestial pole (just eyeball aligning with Polaris isn't good enough).

To accomplish accurate polar alignment, use a finderscope containing a polar alignment reticle or a separate polar alignment tool such as Tuthill's Precision Polar Axis Finder. Or use a star chart showing the exact location of the pole amid the surrounding stars. The star atlas *Uranometria 2000.0*, volume 1, or the index finder cards called AstroCards provide suitable charts.

Once your mount is accurately aligned to the north celestial pole, you could walk away from the setup during the exposure. But many photographers prefer to monitor the tracking by watching a star through the telescope using a high-power eyepiece equipped with crosshairs. Keeping this "guide star" centered on the crosshairs ensures that the mount tracks its target accurately and that stars on the final photo look like stars and not streaks.

Guiding can be quite loose with normal focal length lenses (50mm lenses for 35mm format cameras). Guide stars can be allowed to wander around the field quite a bit before the film shows trailing. Guiding is more critical with long focal-length telephotos.

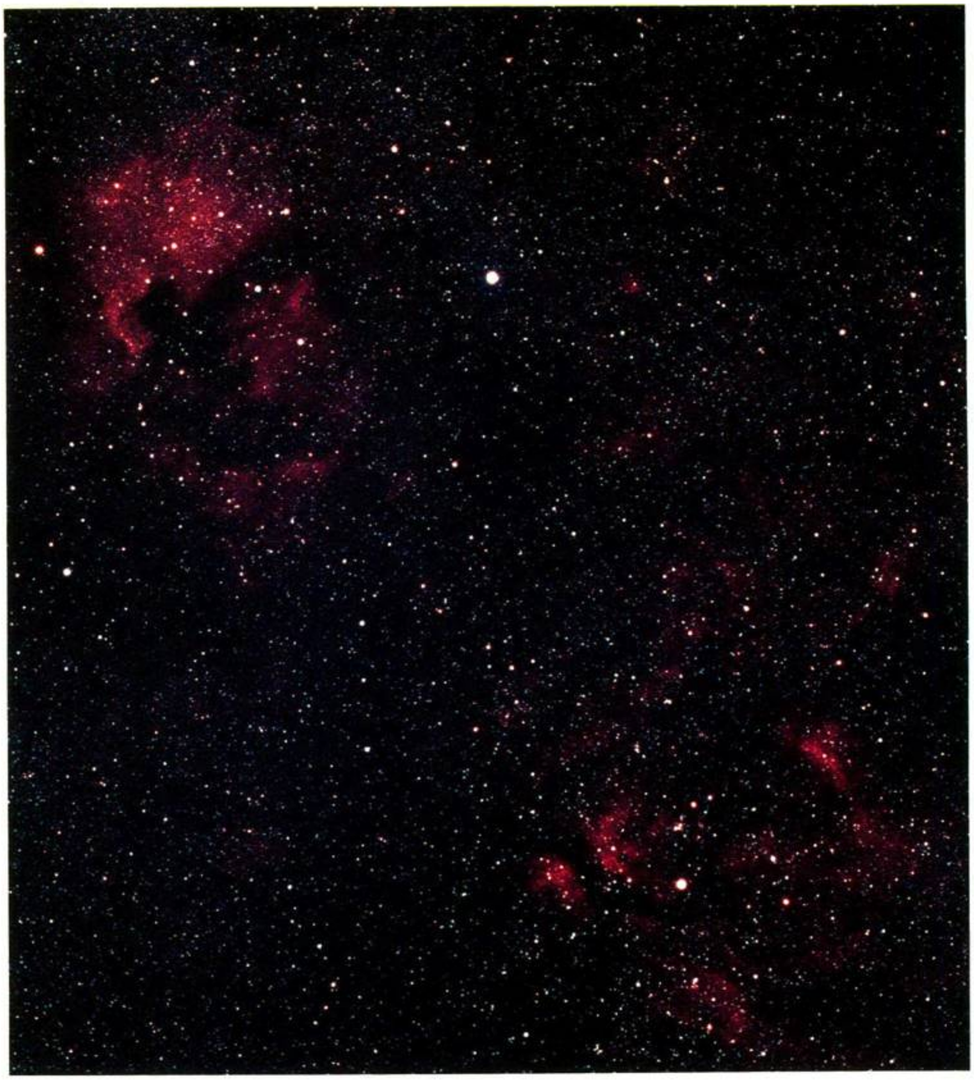
The best type of guiding eyepiece uses an illuminated double-line reticle. The reticle forms a small box in the center of the field; you guide by keeping the star in the box or positioned at one of the corners of the box. If your scope is aligned reasonably well, you should need to tweak the star in declination only once a minute or so. You can even do what I call "intermittent guiding" — just checking the eyepiece once every 30 seconds or so to be sure you're not drifting too far off. A 12mm focal-length eyepiece gives enough magnification for guiding most piggyback photos.

Opening Up or Stopping Down

Start piggyback photography with a 50mm normal lens. (It's the best starter lens because it's the one you probably already own.) Its 27° by 40° field will frame many constellations nicely. Wide-angle lenses, such as 35mm to 15mm models, are useful for large constellations and wide 60°-to-90° sweeps of the Milky Way. Telephotos (85mm to 300mm) are good for selected star fields and deep-sky objects.

Lenses with fixed focal lengths have the best optics; for piggyback applications, a lens should have a maximum aperture of at least f/2 to f/2.8. A good zoom works for constellation shots, but I advise securing the zoom collar with masking tape — my own 35↔105mm has a habit of zooming on its own when pointed up over 45°.

Piggyback photographers soon find that lenses f/2 or faster need to be stopped down one-half to one f-stop to improve star images near the corners. When the lenses are used wide open, an aberration called coma makes stars near the edge look like blobs or seagulls. This can occur with even some of the finest quality lenses. With poor-quality lenses, even stopping down to f/2.8 may not be enough to clean up the star images.



A TELEPHOTO LENS MOVES IN to record the nebulae of Cygnus. Jack Marling used a 135mm lens set to f/2.8 and an exposure of 25 minutes on Fujichrome 400 slide film (developed with color negative chemistry). Marling also employed a Deep-Sky filter to help darken the skies.

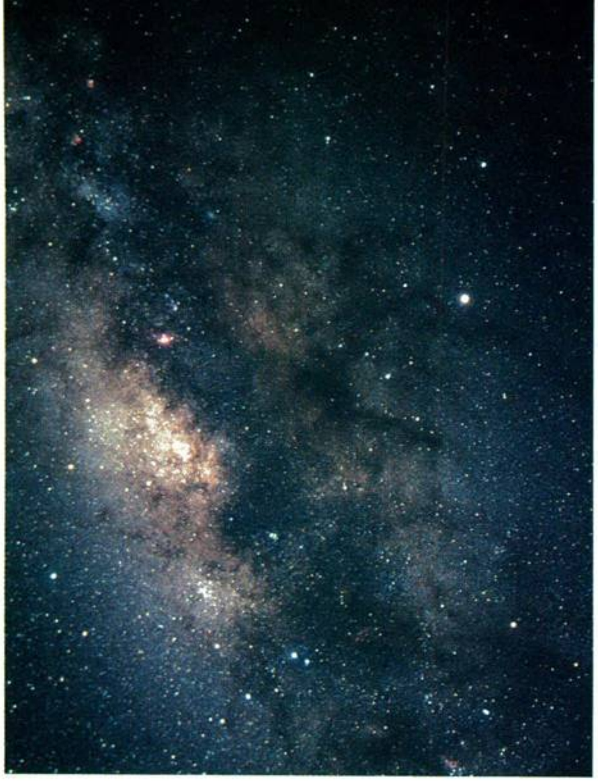
Going Against the Grain

Sometimes poor piggyback photos result not from the choice of equipment, but from the choice of film. If you are happy with 3- by 5-inch color prints as a final result, then ISO 3200-speed film (such as Konica 3200) will work. At those speeds you'll need exposures of only a couple of minutes for most deep-sky targets. After that, even from dark sites, sky fog will wash out the frame.

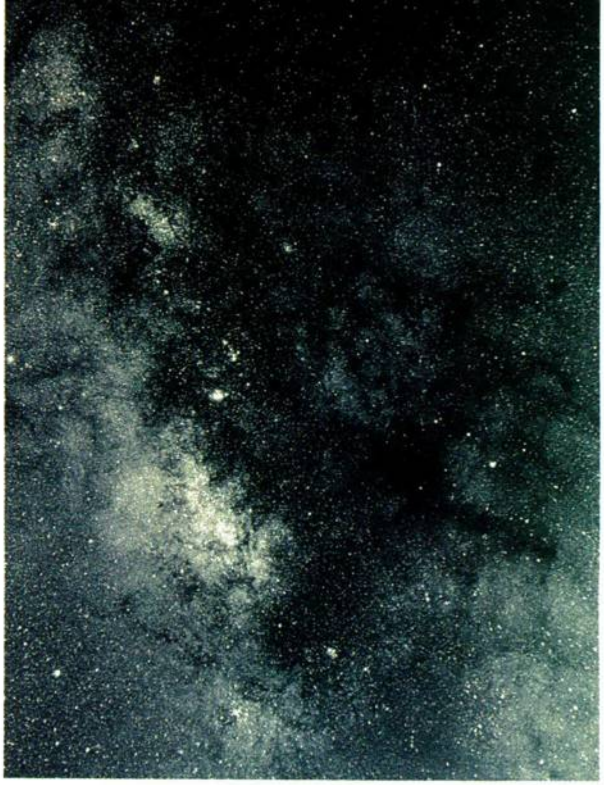
But the grainy negative will run out of resolution long before the lens does. Small objects will be fuzzy and lost in the film grain. I like to stand by a projection screen, focus a 4-foot by 6-foot image of a slide, and still be able to get the feeling I'm looking into space. This is impossible with ISO 3200 or even ISO 1600-speed films.

I prefer to use an ISO 100 slide film and push the film in developing 2 stops to an effective speed of 400. (Most photo labs will push-process film upon request.) The result is better grain and resolution than a 400-speed film normally processed. My favorite for 10 years has been Fujichrome 100D. When pushed 2 stops, this slide film has a background that is less black than the background of a normally processed ISO 400 film (such as Fujichrome 400D), but that serves to show faint objects such as galaxies all the better. I can always darken the background by duplicating the slide and increasing the contrast.

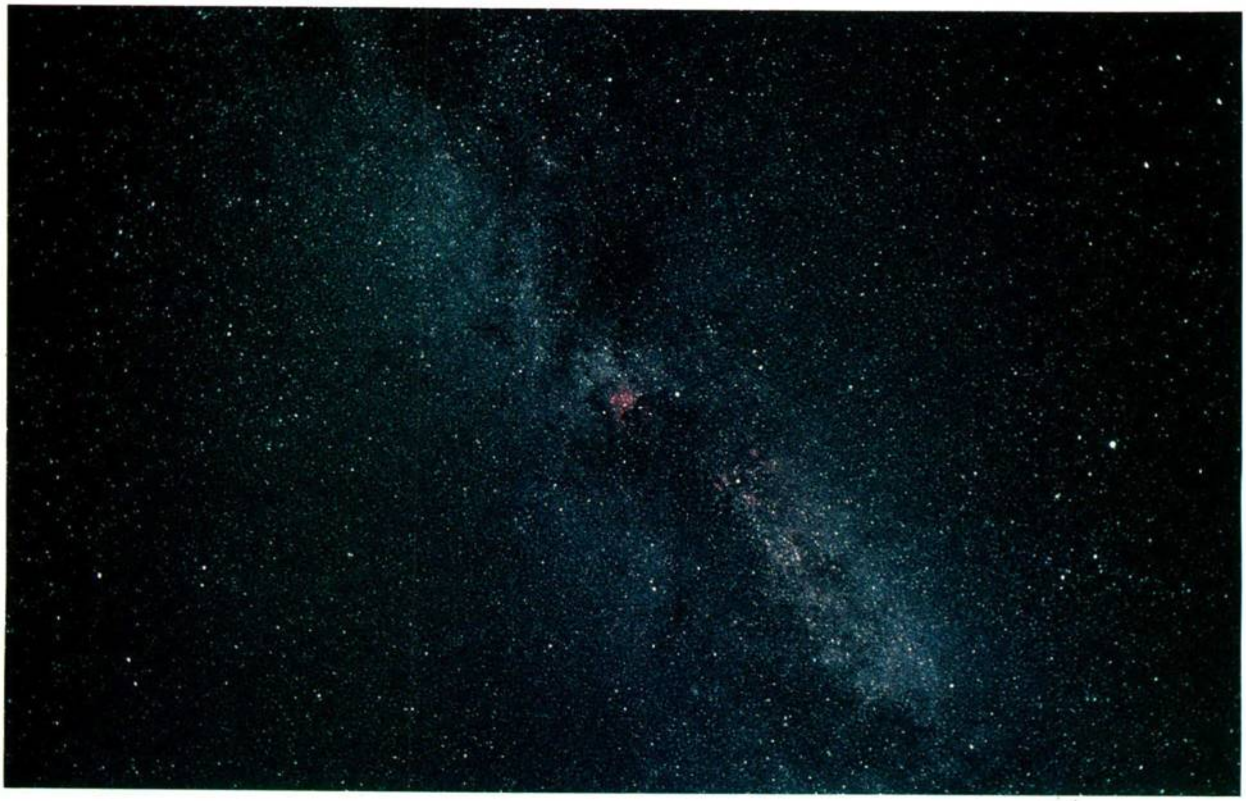
My second choice for its excellent sharpness and very fine grain is Kodachrome 200. It also has good red sensitivity, a requirement for recording red emission nebulae. A professional lab can push this film at least one stop.



COLOR FILM CAN RECORD red patches of nebulosity along the yellow band of the Milky Way. Chris Floyd used a 35mm lens at f/3.6 and ISO 200 film for this 55-minute hand-driven (no motor drive!) portrait of the center of the Galaxy in Sagittarius. Compare this color shot to the black-and-white photo at right of the same area.



BLACK-AND-WHITE FILM CAN RECORD striking contrasts between bright star clouds and fingers of dark nebulae and can produce detailed images better than color film can. For this 15-minute exposure, the author used a 50mm lens at f/2.8 and Ilford XP-1, a film that can record a wide range of brightnesses.



SWITCHING TO A LARGER FILM FORMAT can yield images with finer grain and higher resolution than is possible with 35mm film. For this piggyback shot of Cygnus, the author used a Pentax 6x7-format camera equipped with a 45mm lens (a wide-angle for this format). The exposure was 15 minutes at f/4.5 on Konica 3200 film.

If you don't want slides, then a good 400-speed negative film such as Fujicolor Super HG 400 will prove sensitive enough for most exposures.

Don't bother hypersensitizing color films. Because piggyback photography usually employs fast f/ratios of f/2 to f/4, hypering to boost film sensitivity isn't necessary. Besides, hypering is a lot of trouble and often results in frames plagued by "hyper fog," an uneven sky background unsightly in wide-field images. Combine hypering and color piggyback photography only when you want to employ dense filters or when using a very slow film (like Fuji Velvia or Ektar 25).

How Long and How Wide

The "correct" exposure for any deep-sky photography is a subjective judgement. You could say it is one that shows your subject. But how well? For example, for a constellation's naked eye stars, a few seconds' exposure will suffice. But to reach down to the approximate limit of popular star atlases, say 7th magnitude, you'll need to go 2 minutes or more. This assumes an ISO 100 slide film pushed two stops and a lens set at f/2.8.

Star clouds (bright sections of the Milky Way) will start to record in about 5 minutes. You will start to pick up sky fog after 10 minutes at a dark site. Eventually this fog will brighten the sky unacceptably and wash out any nebulosity you are after. At f/2.8 a normal limit is 15 to 20 minutes with ISO 400 film (or a pushed equivalent). At sites with urban light pollution nearby, the upper limit will be much less, limiting your ability to record faint objects.

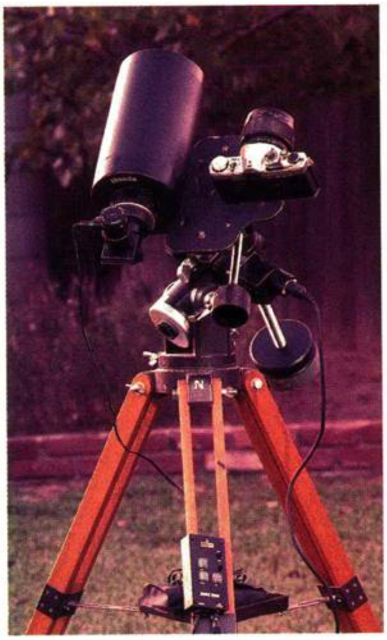
You can reduce sky fog from natural air glow and artificial light pollution by stopping down the lens or using a broadband nebula filter such as a Lumicon Deep-Sky or Orion SkyGlow. These filters work with color film but can affect the color balance by turning sky backgrounds pink. These nebula filters darken skies and increase contrast but require exposures two to three times longer than filterless shots.

Many lenses, especially telephotos, suffer from chromatic aberration — the short wavelength violet and ultraviolet light are not focussed at the same point as the other colors. The result is big blue halos around the brighter stars. A solution is a Lumicon Minus-Violet filter. This filter cuts out the offending short wavelengths but does not require a significant increase in exposure time.

Although many people find filters useful, I prefer to use none at all, including common skylight filters. I feel they introduce ghost images of the brighter stars because of reflections from the back of the filter. The best piggyback photos result when using filterless lenses under dark, transparent skies.

A Black-and-White Issue

Most beginners shoot color film for the aesthetically pleasing results. But a few of us still practice the antiquated art of black-and-white photography. What it lacks in color, a good black-and-white film makes up for in detail, contrast, and the sheer power to record faint objects.



GO PORTABLE, GO PIGGYBACK. Compact equipment, such as the author's Polaris mount and Meade 2045 guidescope, is ideal for go-anywhere astrophotography rigs. A setup like this is all you need for first-class piggyback photos.

The two black-and-white films I recommend are Kodak Technical Pan film (called 2415 in 35mm format) and Ilford XP-1. Tech Pan's fine (almost invisible) grain, high resolution, and extreme sensitivity into the red end of the spectrum make it great for deep-sky photography with any telescope and lenses of any focal length. The catch is that Tech Pan must be gas hypered to be effective for any long exposures. No special development or after-exposure treatment will give it the same sensitivity that gas hypering does. You can hyper films yourself, but if you don't want to mess with high-pressure gases and vacuum chambers, you can buy hypered film from suppliers such as Lumicon.

You will have to develop Tech Pan yourself. To get the maximum speed and contrast, use D-19 developer at 70° F for about 8 minutes. If you don't need this much contrast, use D-19 for 5 minutes or switch to HC-110 or T-Max developers. One of the beauties of hypered Tech Pan is that when combined with a #25 red filter (or better yet a Lumicon hydrogen-alpha-pass filter), glowing hydrogen gas clouds show up with dramatic contrast against black skies. It takes fairly long exposures (about 45 to 60 minutes at f/2.8), but for recording nebulosity the results cannot be matched by any other film or filter combination. This combination also works well even in light-polluted skies. The filter cuts out most sky glow, making it possible for the city-bound to get good piggyback photos.

For crowded and fairly bright Milky Way areas, use Ilford XP-1, a much lower contrast film. Its emulsion is essentially like that of a color film but this is a monochrome (or black-and-white) film. XP-1 has fine grain (not as good as Tech Pan, but fine) but is not sensitive as far into the red as Tech Pan is. Don't use XP-1 for nebulae or in conjunction with red filters. It is, however, excellent for star clouds — the bright areas on an XP-1 frame don't "block up" as they can do on Tech Pan when developed to a high level of contrast.

Whether you shoot specially treated black-and-white film or straight-out-the-box color slides, you'll find that piggybacking your camera is an easy way to enter the world of deep-sky photography. Once you try it and see your first images of rich starfields, you'll be hooked and well on your way to capturing the universe on film. ☐

John Sanford is a member of the Orange County Astronomers and operates an astronomical photography business called Astrostock. His astrophotos have appeared in ASTRONOMY since the magazine's inception in 1973.

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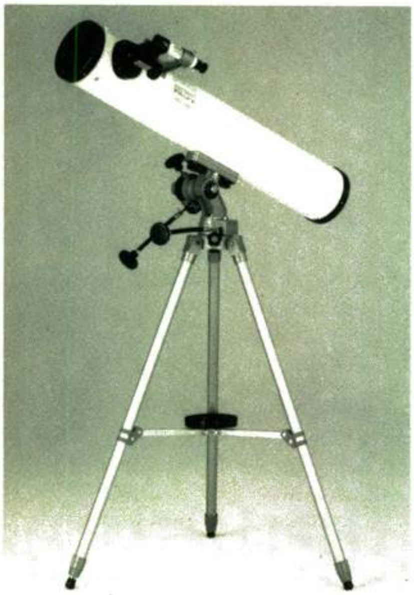

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Own Your Own Piece of THE MOON

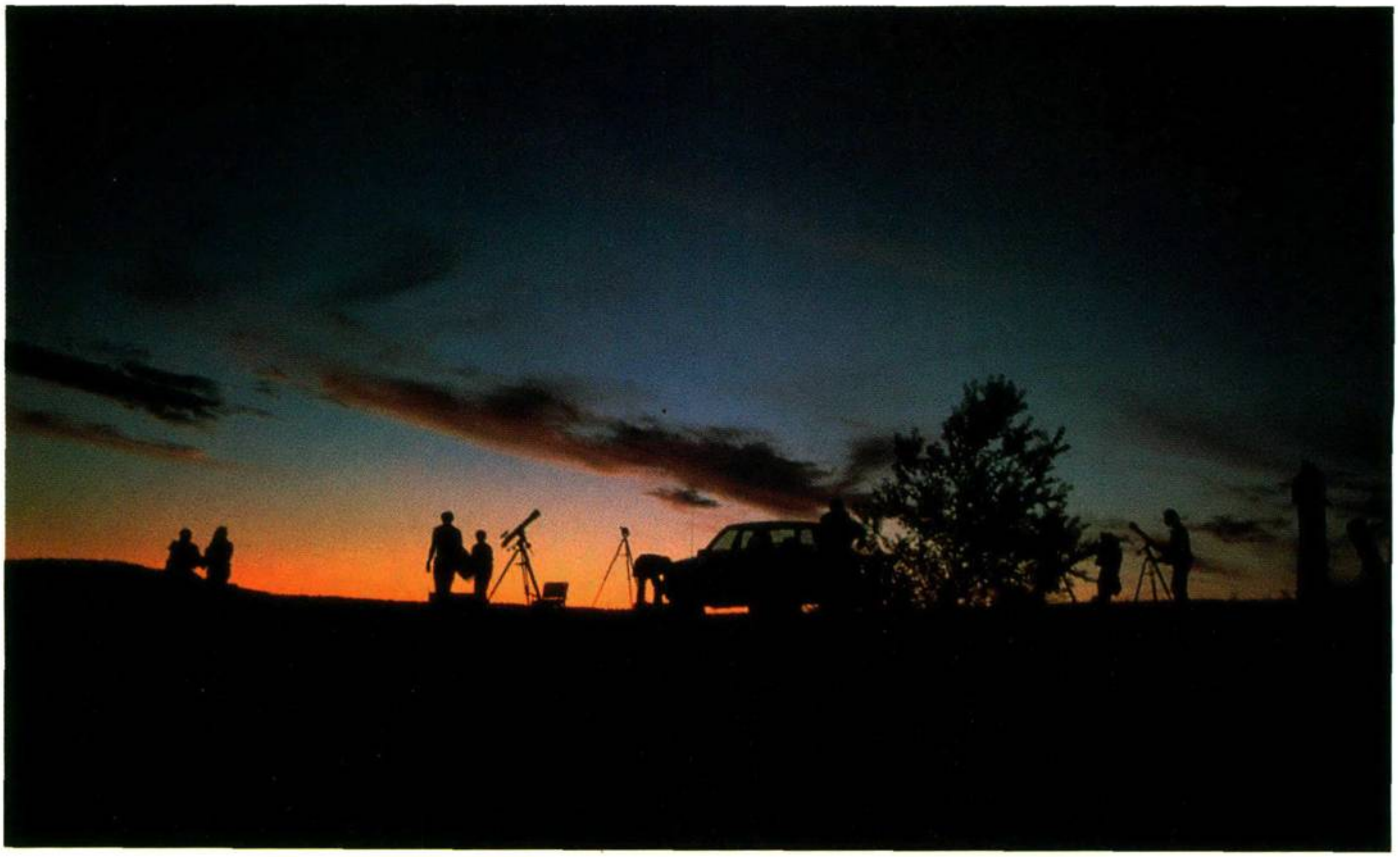
A telescope, a sketch pad, and a little patience is all you need to make your own lunar keepsakes.

Story and sketches by Jim Phillips

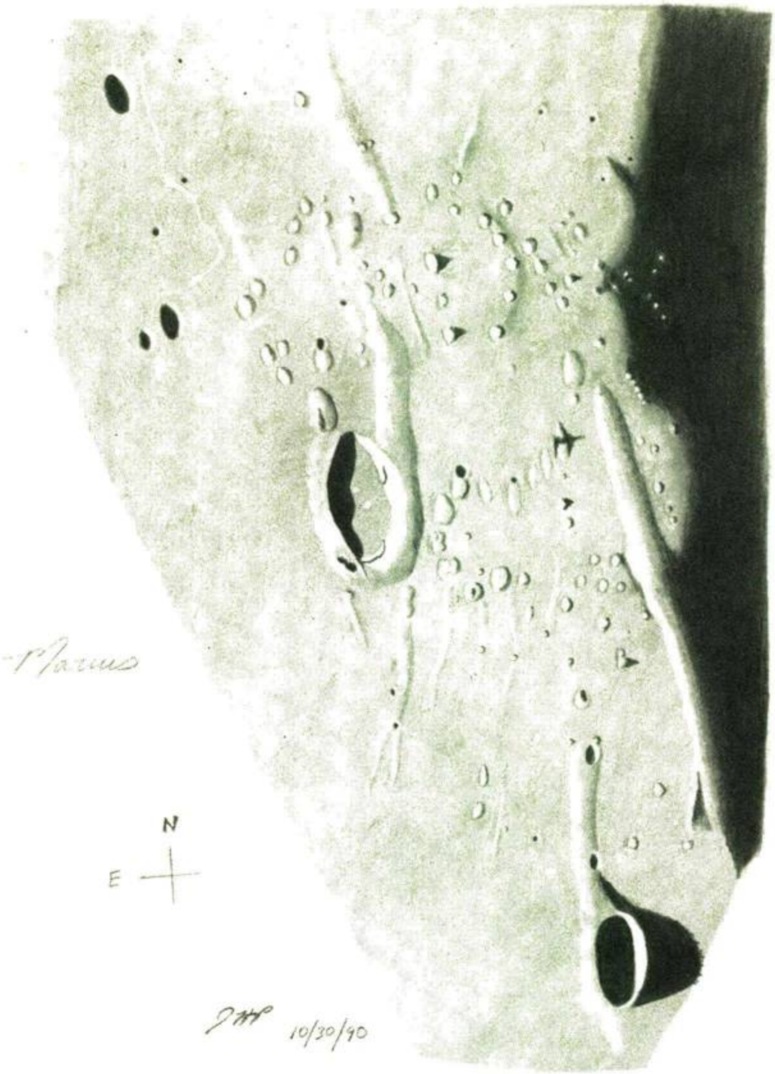
Imagine yourself under a cool winter sky bathed by moonlight, dressed in warm garb, and seated comfortably at your telescope. You stare into the eyepiece at the great crater Copernicus and the area of Moon surrounding it, switch on your faint red flashlight, and cast your gaze down on your lap. There, you open your sketchbook and begin to draw the glowing rim of the giant crater, pencil in the crater's central peak, then switch back to the eyepiece for another prolonged look through the telescope. You switch back and forth between telescope and sketchpad, each time adding a few more details.

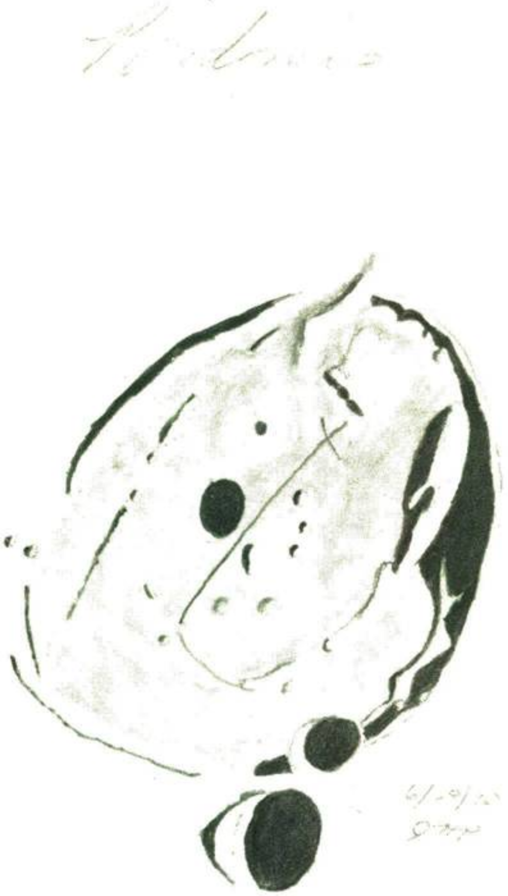
You're not studying for art school but recording the observing sessions you've experienced. There's nothing like making a sketch to capture the way astronomical objects appear to the eye, and there's nothing like the Moon for providing rich detail. Here are some steps for beginners:

Step 1: Gathering Materials. The first step is to purchase the suitable sketching materials from an art or office supply store. I've been making sketches of the Moon for several years and recommend the following pencils and erasers: a #2 pencil (your main instrument), a #2B pencil (for the maria and shading), a #3H pencil (to fill in areas around bright objects), a #6B pencil (for shadows),

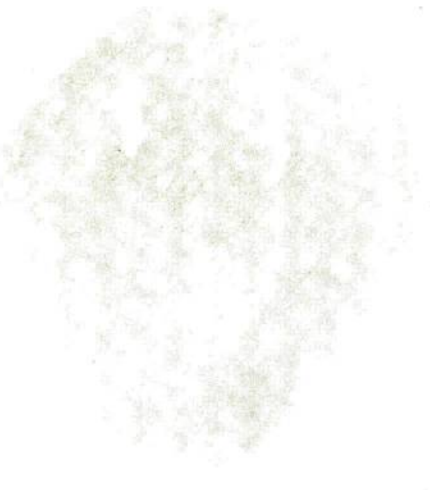


A NIGHT OUT UNDER THE STARS can be productive when you sketch the Moon with telescope, pencil, and paper. The Moon is rich in detail, and sketching provides a record of your observations and teaches you better observing skills. Photo by Alan French.

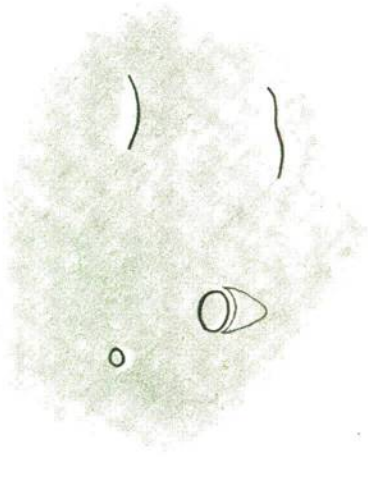




PENCIL AND PAPER record the subtle shadows, bright crater rims, domes, and wrinkle ridges of the Moon's surface. Fine details appear near the crater Marius (left); minute details appear in the crater Poseidonus (above); and sunrise illuminates the region of Marius (opposite page). All sketches made with a 6-inch f/12 apochromatic refractor at various magnifications.



THE ANATOMY OF A SKETCH shows each stage going into a final drawing. The first step involves rubbing on a light background of graphite and then erasing areas that stand out brightly. The second is adding dark features that define crater walls, ridges, and so on. The author uses a photographic atlas to check an object's position.

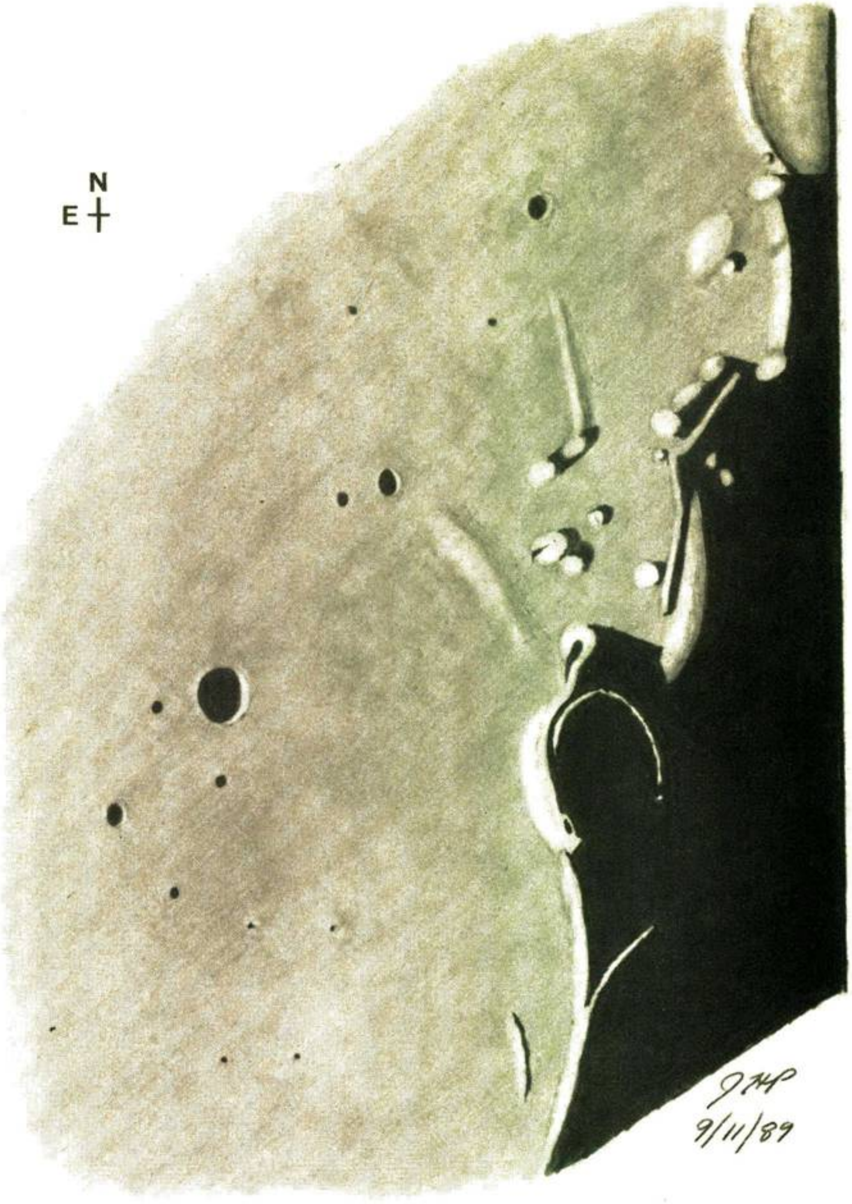


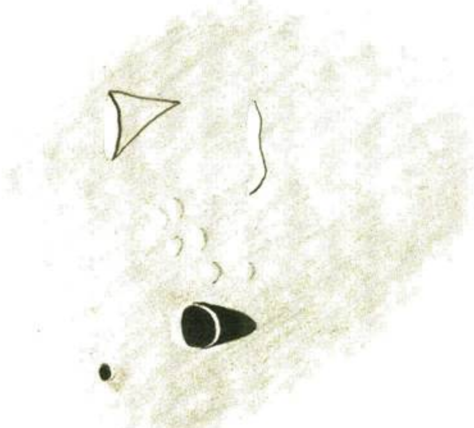
hard and soft erasers (for removing and changing details), and an artist's stump (for smudging and creating shadings). Paper is important: I recommend the best quality white stock you can afford. My logbook is a hardbound sketching book with acid-free paper that measures 8½" by 11". This type of book doesn't flop around on my lap while I'm out under the stars. To make finished drawings, I use 2-ply, Bristol 100 percent cotton fiber paper.

Step 2: Making Field Notes. Take a dim red flashlight and sketching material outside with you. Set up your telescope and get comfortably seated. Now you're ready to make your first drawing. To begin, I hold the logbook and flashlight in my left hand while I draw with my right. I work slowly from one object to the next, drawing what I see, and make notes about everything from lengths of shadows to intensities of bright and dark areas.

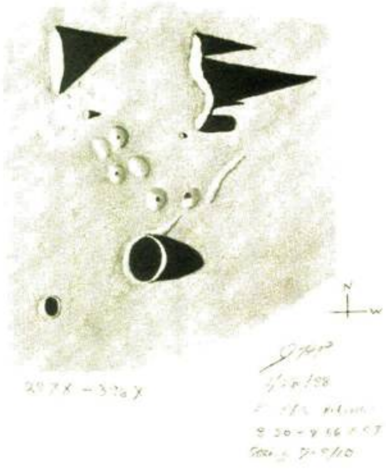
Once I add a lot of detail to a drawing I work carefully on such areas as crater floors. I look for and record domes, wrinkle ridges, and other low-relief structures casting shadows and standing out with great contrast. As I make the drawing, I change magnification back and forth and try filters in hopes of picking up additional detail. I wait and catch those few seconds at a time when Earth's atmospheric turbulence settles down and fine detail pops out. I then transfer the detail as accurately as possible to the drawing.

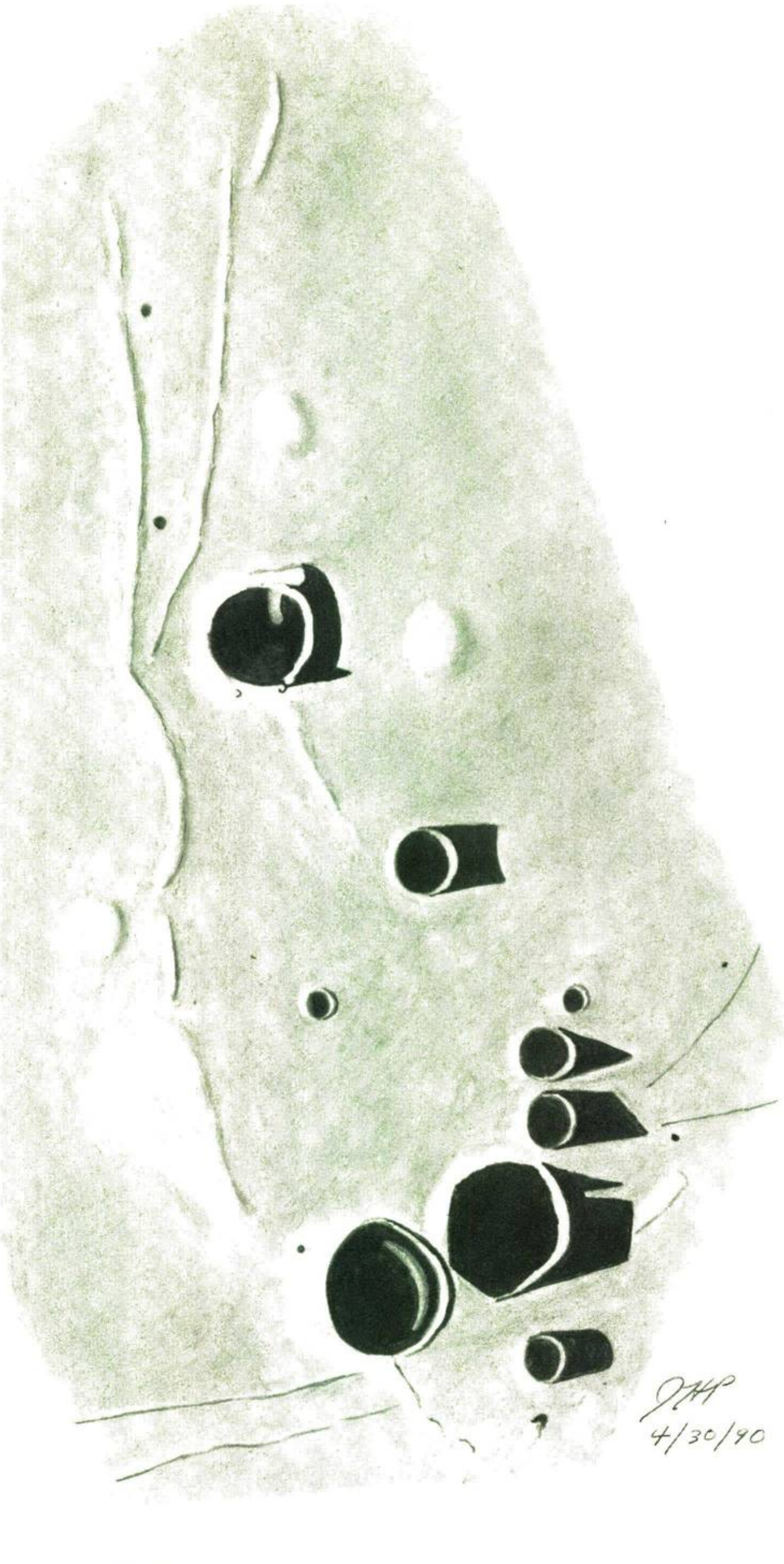
Step 3: Copying Notes to Final Form. When I've finished drawing





THE FINAL RENDERING. In the third step, the author draws dark features representing shadows and subtle details on the Moon's surface. The final step involves adding additional features to finish the moonscape, completing the shadows from prominent features, and finishing the fine details within complex areas.





REALISTIC LUNAR LANDSCAPES result from carefully drawing complex regions on the Moon, regions such as the area of Arago.

what I see in the eyepiece, I bring in the "field sketch" and prepare to make a finished sketch. I take the original drawing to my study and trace major craters and mountain groups from Gerard Kuiper's *Photographic Lunar Atlas* onto a template — a transparent sheet of paper. I don't trace or add any objects that aren't on my original drawing, but simply use the tracing to position objects accurately and to get the outlines of features correct.

By alternately placing the template on top of the final sketch and then removing it and drawing in some detail, I can record all of the features from my field sketch onto the finished drawing. First I shade the area using even strokes with the pencil, and then smooth the entire area with an artist's stump. I then place the template over the drawing so that objects are positioned accurately. I move across the drawing from left to right, drawing in the craters and mountain ranges, using my original drawing as a guide to shadows and fine detail.

Step 4: Spraying to Fix the Drawing. Once I've finished the drawing, I use a fixative spray to prevent smudging. As a final stage, I take the drawing to a local art shop and have it shrink-wrapped in plastic. I recommend that the date and time, magnification, telescope type, and seeing conditions be added to either the front or the back of the drawing.

Sketching the Moon captures the great lunar features as your eyes see them — not as they're recorded on a photograph. But when you're out under the telescope visually observing, looks are fleeting — images fade away with the morning's sunrise. So why not sketch and keep the memories forever? Besides, what better way to disprove the 20th-century poet William D. Snodgrass, who wrote, "It was the nature of the thing: no Moon outlives its leaving night." Ah, but so many pretty Moons live on in the pages of my sketchbook. □

Jim Phillips is an anatomical and clinical pathologist in Charleston, South Carolina.

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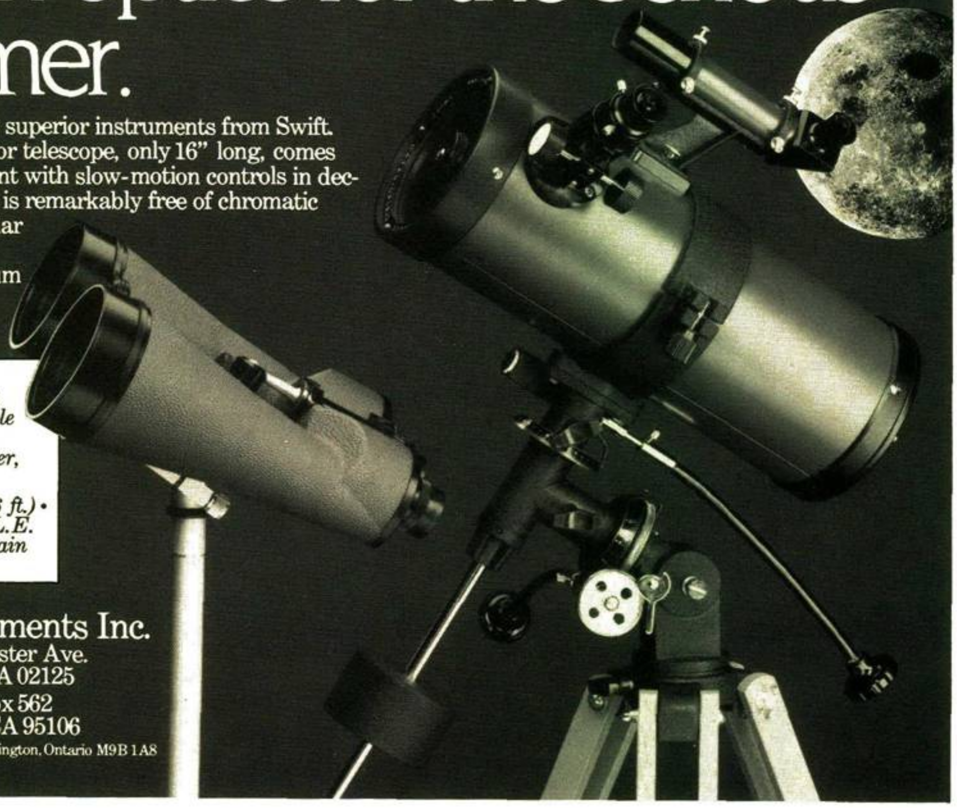

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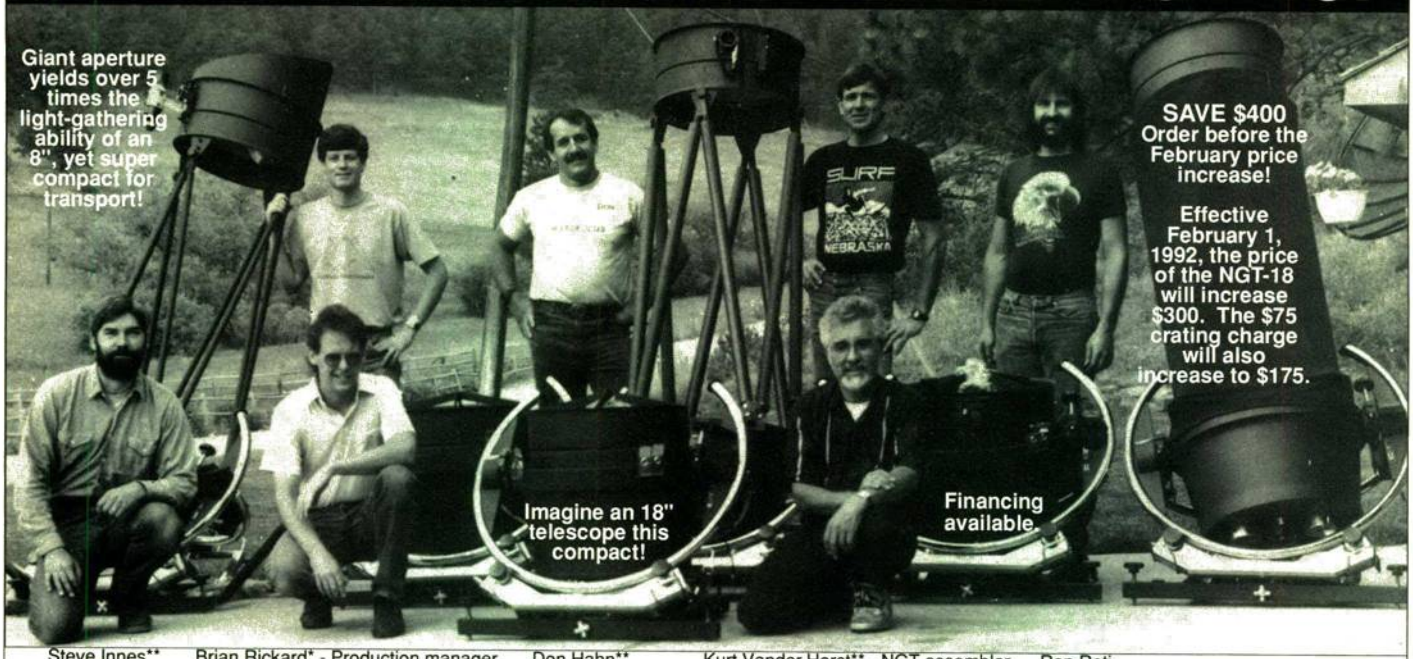

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S92A2

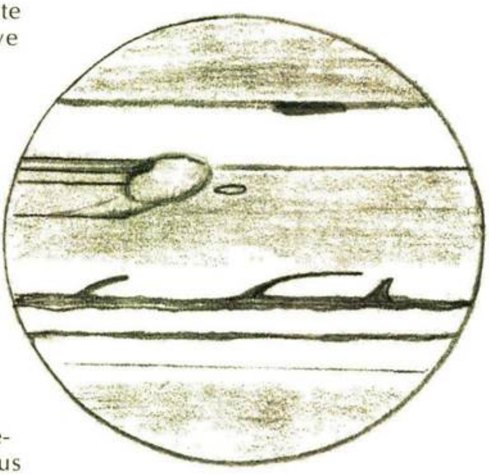
PLANETARY OBSERVING ROUNDUP

Reader involvement in observing and photographing the planets seems to be growing by leaps and bounds, judging by our mailbox. Of particular interest during the first months of 1991 were Jupiter and Venus, offering spectacular views of planetary details and changing phases for telescopes large and small.

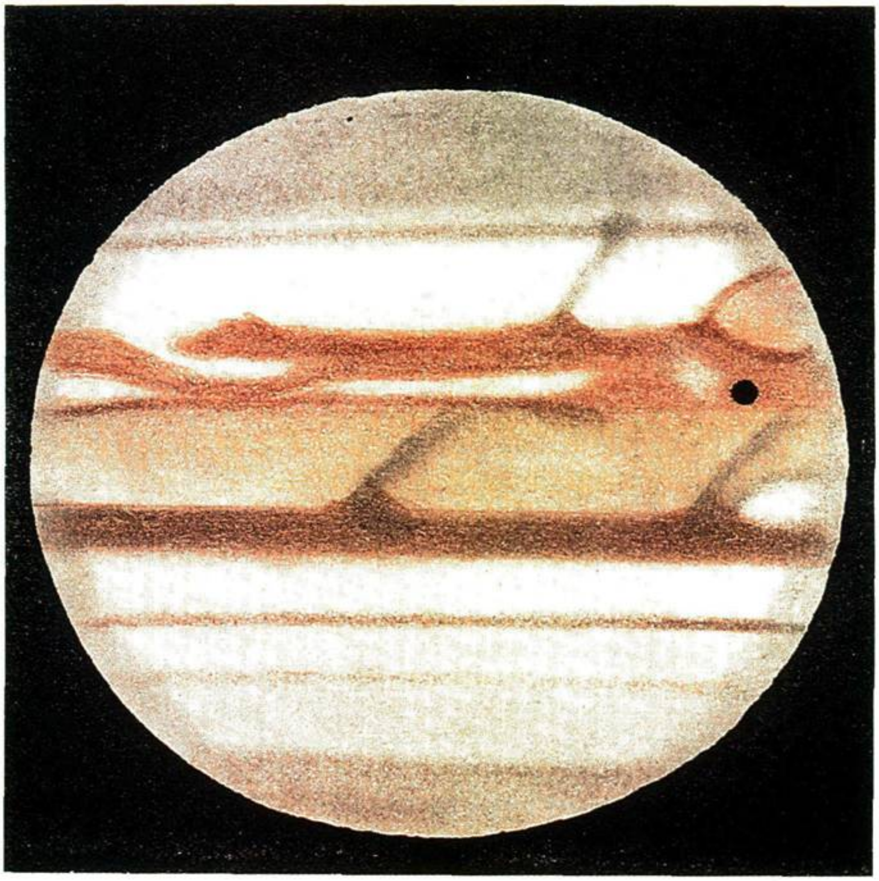
All Eyes on the King of the Planets. Because features in its cloudtops have changed significantly in recent months, Jupiter has attracted the most attention. British observers Paul Smith and Matthew Boulton observed Jupiter's changing features regularly throughout 1991 from sites in Redditch and Darlington, England. "We endured freezing temperatures last winter and witnessed bright rifts, dark bulges, and projections from the South Equatorial Belt," says Boulton. On January 1, 1991, the observers spotted several white spots in the northern part of the SEB and a large white rift between the South Tropical Zone and the SEB.

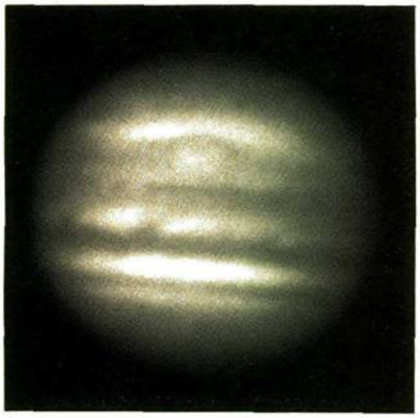
Observing from Edmonton, Alberta, Randy Pakan sketched Jupiter throughout May and reported exquisite details. "I can't help noticing the lovely warm hues that vanish as soon as the sky becomes dark and the contrast increases," reports Pakan. "Split seconds of good seeing reveal so much detail on the planet that your brain can't register it all! On May 7, for example, I observed two tiny white ovals south of the North Temperate Belt. This season the details have been really incredible."

Monitoring a Hellish World. Between May 25 and June 24, 1991, six members of the Mohawk Valley Astronomical Society in Utica, New York, conducted a Venus watch. The goal was to monitor Venus' changing phase and determine when Venus reached half phase. "We sent our observations to the Association of Lunar and Planetary Observers," says Perry Pezzolanella, one of the participants. By plotting their measurements of the illumination of Venus versus time, the club members determined half phase occurred on June 7, five days earlier than planetary astronomers predicted. This demonstrated Schroter's effect, an unexplained phenomenon that suggests Venus appears at half phase at irregular intervals. — *David J. Eicher*



JUPITER LOOMED LARGE in the observing activities of amateurs during the first months of 1991. On the first day of the year, Paul A. Smith of Darlington, England, made a colored pencil sketch of the planet with his 6-inch f/6 reflector at 150x and 200x (right). Randy Pakan of Edmonton, Alberta, produced a sketch of the planet and its Red Spot on May 3, using a 16-inch reflector at 285x (above right). Gregory Terrance's photo of Jupiter shows the Red Spot's appearance on March 29 (below).



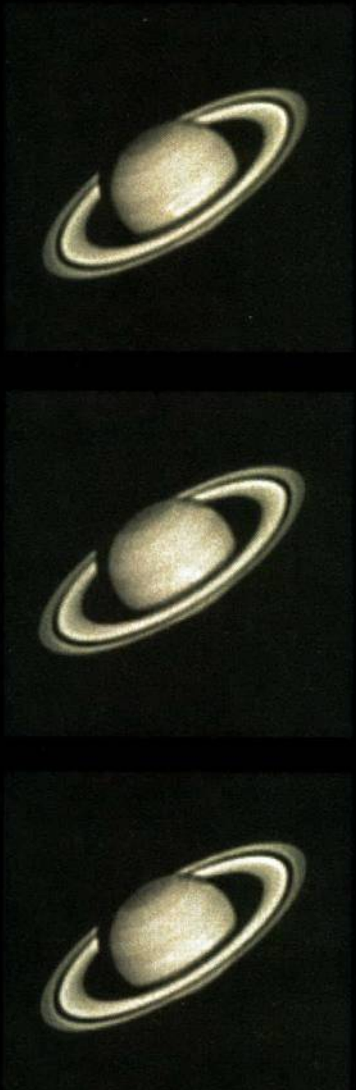


ORION'S CURTAIN OF DUST AND GAS

The constellation Orion is not only the brightest, most easily recognized group of stars in the winter sky. Seen on a different level, this area of sky holds a thick, faintly glowing blanket of nebulosity that includes the bright spots observers know as the Orion Nebula, M78, and the region around the Horsehead Nebula. Central Orion also contains a large arc of faint nebulosity called Barnard's Loop, a cosmic bubble blown by the stellar winds from hot stars. Michael Stecker's photo of the area (opposite page) wins this month's $100 "Best Astrophoto" award. Stecker used a 180mm f/2.5 lens, hypersensitized Tech Pan film, a hydrogen-alpha filter, and a 70-minute exposure.

Another recent outstanding example of deep-sky photography is Kim Zussman's image of Abell 2151, the Hercules Cluster of Galaxies (below).

Astrophotographers have not abandoned the solar system, however. A specialist at high-resolution solar photography, Gordon Garcia of Hoffman Estates, Illinois, recorded a particularly detailed image of a sunspot on June 8, 1991 (above right). L. Allen Beers was lucky enough to get a two-for-one special: on the night of August 3, he captured a bright meteor streaking past a glowing display of aurora (top). And expert CCD imager Donald C. Parker of Coral Gables, Florida, recorded a stunning sequence of Saturn images (right). Parker used a 16-inch f/6 reflector, a Spectrasource Lynxx CCD camera, and 1.3-second exposures. The images were made on September 29, 1991, at 0h26m, 1h02m, and 1h21m UT, and show the planet's rotating and changing cloud features.



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Astronomy Books

LOOKING FOR THE DARK FORCE

The Shadows of Creation, by Michael Riordan and David N. Schramm, (W. H. Freeman, 1991), ISBN 0-7167-2157-0, 255 pages, hardcover, $18.95.

Up quark, down quark, strange quark, muon. Lepton, nucleon, baryon. Tau neutrino.

Some weird cabalistic incantation? It might as well be if you're not a student of particle physics. Actually, these and other strangely named bits of atomic matter lie at one of cosmology's research frontiers, which Riordan and Schramm do an able job of explaining for the general reader interested in astronomy.

The Shadows of Creation takes you into the realm of the smallest bits of matter we know of and then sails out to the farthest reaches of the explored universe — all in search of the mysterious dark matter that appears to make up over 90% of the cosmos. The authors examine the attempts by astrophysicists to describe and understand this dark matter and tell you what they have learned about it.

Gravity is the clue. It affects everything and is a force within everything. It holds us to the ground and keeps the Moon orbiting Earth and Earth, the Sun. It keeps the Sun from flying out of the Milky Way, and it keeps our Galaxy in the fold of the Local Group of galaxies. By studying the motions of galaxies under the force of gravity, both singly and in groups, astrophysicists have concluded that all the matter we see is only a tiny fraction of that necessary to make stars and galaxies move as they do. Where then is this unseen "dark matter"?

As they develop an answer to this question with the aid of many easy-to-understand graphics, Riordan and Schramm take the reader step by step through the processes cosmologists use to explain how the universe began and where it is going. They probe the differences between the Big Bang and Steady State cosmologies and explore the possible ends of it all in the Big Chill or the Big Crunch.

In the Big Chill, the universe will forever continue to expand and cool off because there isn't enough matter (therefore gravity) to stop the expansion. The Big Crunch, however, is the fate of a universe containing enough matter to halt the observed expansion and throw the Big Bang into reverse gear.

Cosmology is the science of how it all began and where it's going. Like many people, I am fascinated by this subject and couldn't put the book down until I had finished it. — *Robert A. Garfinkle*

The Cosmic Water Hole, by Emmanuel Davoust, (MIT Press, 1991), ISBN 0-262-04114-6, 206 pages, sewn binding, hardcover, $19.95.

Davoust, an astronomer at France's Observatoire Midi-Pyrénées, asks one of the biggest questions in the whole field of astronomy: Are we alone? He provides no definitive answer, of course, to the extraterrestrial life question. But besides writing an interesting book that reviews the requirements for life in the universe and the chances we'll find it elsewhere, he also explores what this search for life means to us on Earth. Unlike the bland rehashes often served up on the subject, this book has a personal tone that gives it interest for anyone who has already delved into the field. It finishes with a 14-page bibliography (yay!) but lacks an index (boo!).

The Natural History of the Universe, by Colin Ronan, (Macmillan, 1991), ISBN 0-02-604511-7, 212 pages, sewn binding, hardcover, $39.95.

This book is like a video that doesn't quit. While it is intended as a popular-level overview of astronomy and cosmology, hardly a spread goes by without the reader's being blasted by color images, many of them computer-processed into vivid hues. Threading past the images is a sober and straightforward text that adequately does its job of explaining the universe, its origins, future, and contents.

Yet I couldn't help wondering how this book would play to the general public. I guess what worries me is that the bright false colors will give kids and other beginners in astronomy a totally false impression of what the subject is actually like — and a likewise false impression of what backyard astronomy is about. I mean, it's great to use video techniques to catch the attention of people raised on videos, but what happens when they find out the night sky isn't like that? — *Robert Burnham* ☐

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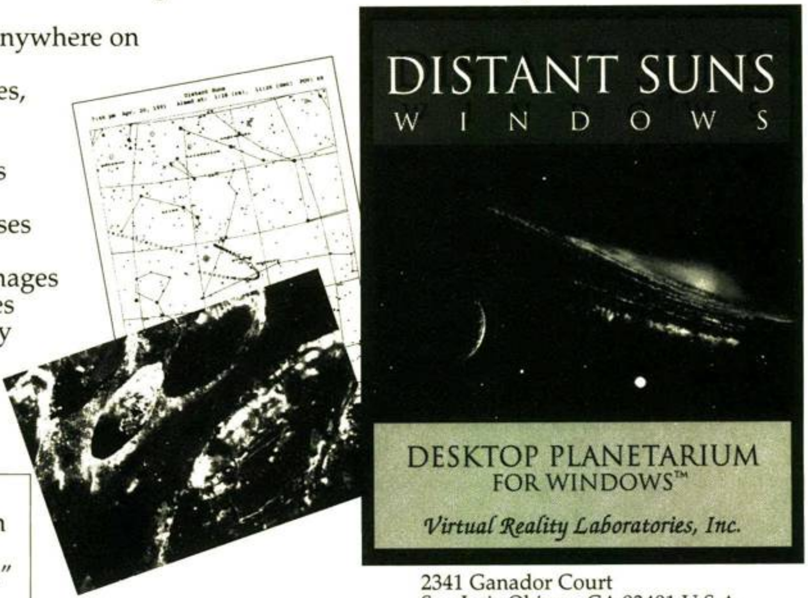

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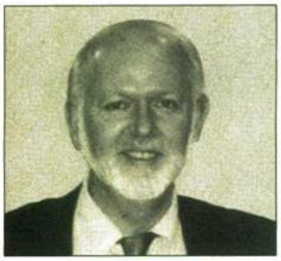

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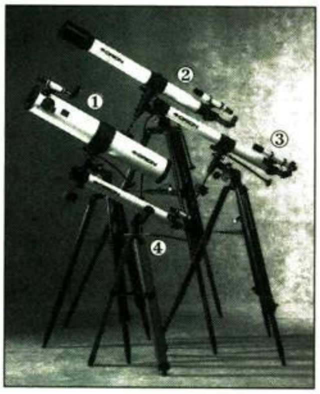

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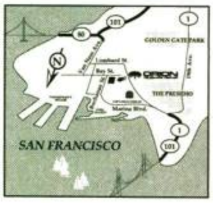

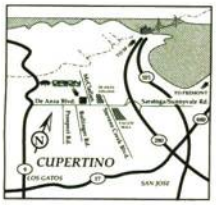

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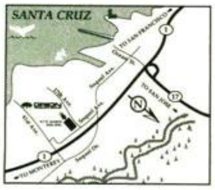

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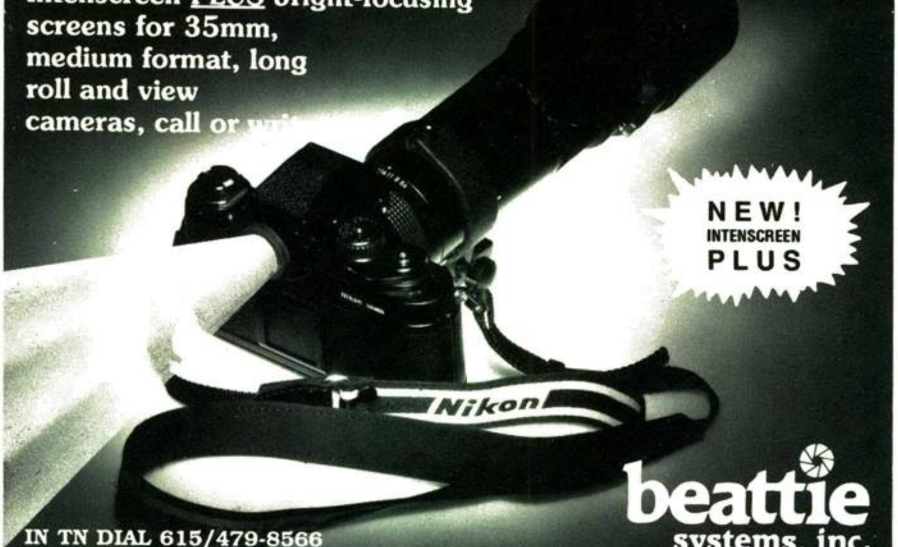

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NGP — The Revised New General Program for Nonstellar Astronomical Objects. *Public domain program by Gary Dean Williams. Send five 360K DD 5.25-inch diskettes with SASE to Gary Dean Williams, c/o Gary Liptrot, 511 S. 775 E Street, Ogden, UT 84404. Requires IBM or compatible computer with 512K RAM, hard disk with at least 2 megabytes of free space, and a printer. Also available via modem from the Astronomical League's Stargate Bulletin Board [(214) 578-7618 (8,N,1)].*

Soon after getting my personal computer several years ago, I discovered a number of astronomical programs were available for the IBM PC. But it seemed that few of these programs could help me with my two primary needs as a deep-sky observer: developing lists of objects to observe and logging my impressions of what the objects look like in a standardized, easy-to-use format.

In his NGP program, Gary Williams has responded to both these needs and provided a strikingly easy way for observers to exchange observations with one another, either by sending diskettes or via modem.

The basis of the NGP is the Revised New General Catalogue (RNGC), a listing of 8,164 nonstellar objects, including galaxies, globular and open clusters, and various types of nebulae. The NGP allows you to sort through the RNGC in any number of ways to help you develop lists of objects to view. One method is to use the NGP to list only objects brighter than the limiting magnitude of your telescope. Another is to assign right ascension and declination limits to "window" a particular section of sky. A third option is to compose a listing of just one or two types of objects.

But my favorite method of sorting the RNGC is by entering user-defined object lists, a feature I believe is unique to the NGP. Perhaps you have just finished reading an article in ASTRONOMY about galaxies in the spring sky. The NGP allows you to enter the NGC numbers of the objects listed in the article and then presents you with a display of the basic RNGC data for those objects.

NGP's primary screen is divided

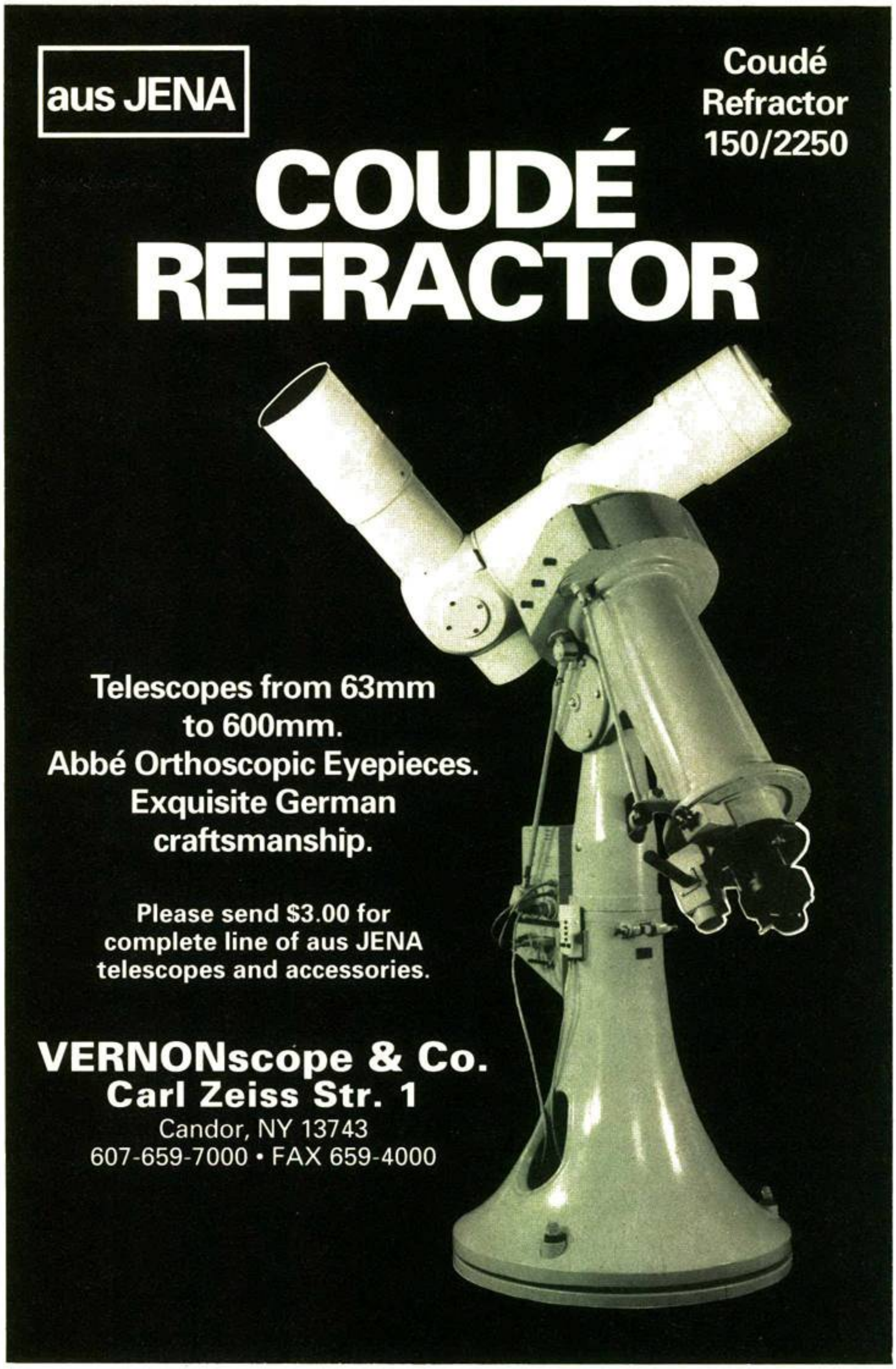
into three parts. The left side makes up the "selection set editor," a listing of different options that help you sort through the database. The right side of the screen displays basic information on up to 20 RNGC objects, including the right ascension and declination, the type of object, and the constellation in which each object is located. A third, smaller window of options appears in the center of the screen. From this window you can either work with the selection set editor, produce printouts of your lists of objects, or page through and highlight any displayed RNGC object. Once a particular object is highlighted, hitting Return displays a full screen of information on that object.

It is here that the NGP separates itself from most other astronomical database programs. The top of the screen displays the full extent of the RNGC description. Using information in the program's documentation (which is supplied on disk) you can decipher the infamous coded RNGC abbreviations that describe the object's appearance.

The bottom half of the screen is reserved for your own personal notes. Once typed in, the notes are saved by the NGP for future reference. You can also export your notes to a separate file which can then be exchanged with a friend who has the NGP.

If you have an additional 2 to 8 megabytes free on your hard drive, the importing of notes can provide another service that gets around some of the limitations of the RNGC database — notably that its fainter magnitude figures can't be trusted and that the RNGC is missing some useful information such as the sizes of galaxies. Williams has helped solve this problem by producing a series of import files with information from catalogues like the Uppsala General Catalogue and the Morphological Catalogue of Galaxies.

The biggest problem I found with the NGP was minor and affects only southern hemisphere observers. The original RNGC notes if an object is located in one of the two Magellanic Clouds, but the NGP selection set editor does not allow you to sort for objects located in these two southern-sky galaxies. In addition, it would be nice if future versions of the NGP could automatically decipher the RNGC description codes, making it much less time consuming to determine an object's appearance. — *Robert Bunge* ☐



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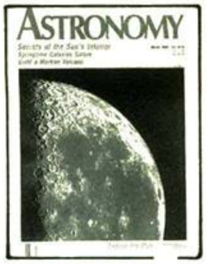

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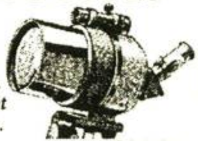

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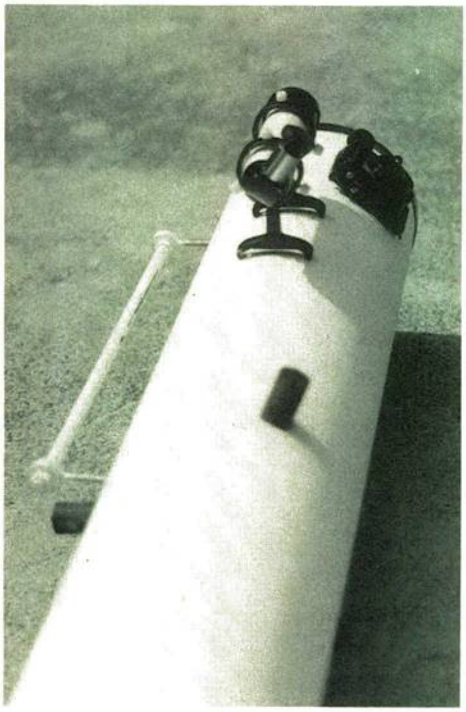
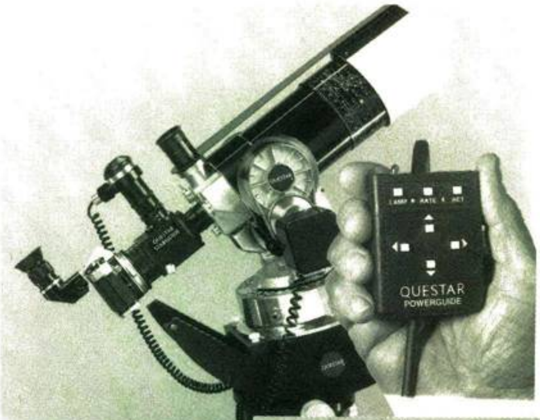
New Astronomy Products

1 High-Resolution Newtonians

Parallax Instruments is offering a line of long-focus Newtonian tube assemblies designed for high-contrast, high-resolution views of the Moon and planets. The optics are guaranteed to be diffraction limited and are said to deliver refractor-like sharpness. A variety of focal ratios are available. The tubes are lined internally for stray light absorption and feature ultra-low profile focusers and 7x50 finderscopes. Complete equatorial mounts will also be offered soon.

Parallax Instruments, Suite 708, Box 192, 8318 Pineville Matthews Road, Charlotte, NC 28226, (704) 542-4817. Tube assembly prices: 4.25-inch: $795, 6-inch: $995, 8-inch: $1,245, 10-inch: $1,645, 12.5-inch: $1,995.





2 New Accessories from Questar

Questar introduced new versions of the Powerguide and Declination Drive (both shown above right) that feature stepless motors whose rates are adjustable via a palm-sized hand controller. The Powerguide varies the right ascension tracking speed for astrophotography and allows users to select lunar or sidereal rates. It operates from a built-in 9-volt battery or from 110 volts AC and can be retrofitted into the base of older model Questars. The Declination Drive motor attaches to the side of the telescope and allows for fine dual-speed motion in declination.

Questar has also introduced two new piers made of black-anodized, machined aluminum. The 41-pound Astro Pier (above left) places the eyepiece height at approximately 56 inches. It includes casters and leveling pads. The smaller 15-pound Tri-Stand (above) places the eyepiece at approximately 41 inches. Optional accessory shelves are available for both.

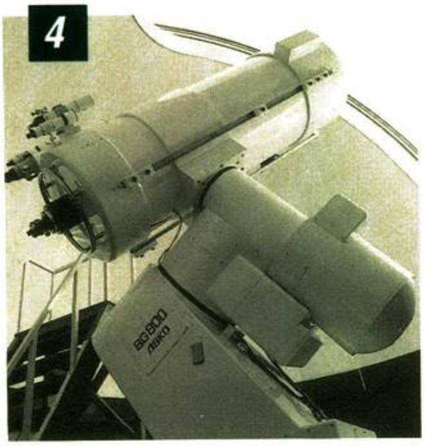
Questar Corporation, P.O. Box 59, New Hope, PA 18938, (215) 862-5277, FAX: (215) 862-0512. Powerguide (retrofitted to older 3.5-inch scopes): $326, Declination Drive: $260, Astro Pier: $1,450, Tri-Stand: $965.

3 TowerPower™ Computer

Lewis-Michaels Engineering, the developers of the GENESIS PROJECT astronomical software, is offering a low-cost IBM-compatible computer. The system features a 80386 25MHz processor, a 230-watt power supply, and a socket for an 80387 math co-processor. The computer comes with the GENESIS PROJECT software (valued at $299.95) and a one year parts and labor warranty.

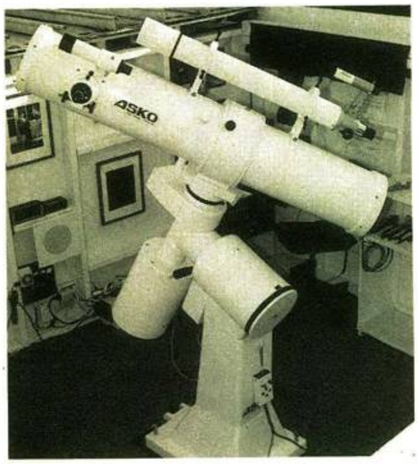
Lewis-Michaels Engineering, 48 Delemere Boulevard, APA386, Fairport, NY 14450, (716) 425-3470. $995.95.

4



RVR/ASKO Observatory Telescopes
R.V.R. Optical has announced their latest observatory-class instruments, the 31.5-inch ASKO Newtonian/ Cassegrain (shown above) and an 8.25-inch Newtonian telescope (shown below). Both are available on a worldwide basis exclusively through R.V.R. Optical. Send $5 ($10 for foreign orders) for a complete information package.

R.V.R. Optical, P.O. Box 62, Eastchester, NY 10709, (914) 337-4085.



5 Video on Buying and Using a Telescope

Well-known amateur astronomer Charles Scovil hosts this 40-minute video that describes all aspects of telescope purchase and use for the novice astronomer. The video, entitled *A Practical Approach to Buying and Setting Up Your First Telescope,* was produced in a professional New York television studio and on location.

Business Education Concepts, P.O. Box 1007, Green Farms, CT 06436. $29.95 plus $2.55 shipping and handling. Connecticut residents add $2.40 sales tax. Available only in VHS format.

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One Grand Prize will be awarded from all entries received by January 31, 1992.

Here's how to *Play*

- To enter, complete the Official Entry Form bound into this issue.
- You may use the Official Entry Form to subscribe to ASTRONOMY, but you do not have to subscribe to enter. If you already subscribe to ASTRONOMY, this is the perfect opportunity to renew your subscription.
- First, Second and Third Prizes will be awarded three times: once from the November 1991 issue entries, once from the December 1991 entries and once from the January 1992 entries.
- Send in the Official Entry Form (no reproductions, please) from the November, December and January issues of ASTRONOMY, and triple your chances of winning.
- The Grand Prize, a Questar Telescope and Solar Observatory, will be awarded once from all the November, December and January entries.
- If Official Entry Form is missing from this magazine, send a postcard with this magazine's issue date and the name of the store where you purchased your copy to: ASTRONOMY Sweepstakes, P.O. Box 1612, Waukesha, WI 53187-1612. Cards must be postmarked by the last day of this month.

a Questar Telescope!

Prizes awarded from every month's entries — in November, December and January.

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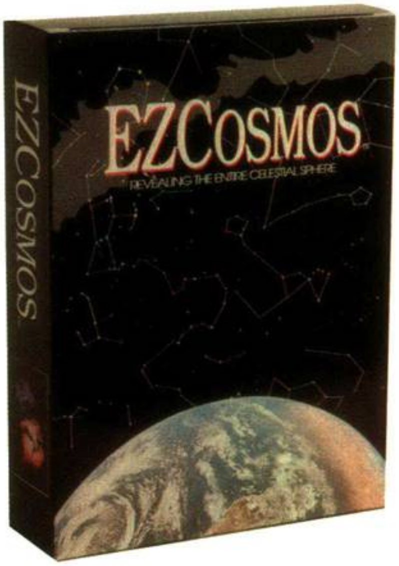

2nd Prize

EZ Cosmos Software

You could win a trip to anywhere in the universe. EZ Cosmos reveals the entire celestial sphere for any location from 4000 BC to AD 10000. Explore more than 10,000 celestial objects — zoom in on stars, verify historical observations and watch solar eclipse animations. Version 3.0. Retail value: $69.95.

Two Second Prizes will be awarded from every month's entries — in November, December and January.

3rd Prize

Three-year subscription to ASTRONOMY

Each month, eight winners will be awarded three-year subscriptions to ASTRONOMY magazine. If you are currently a subscriber, the prize will begin after your subscription expires.

Eight Third Prizes will be awarded from every month's entries — in November, December and January.

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1. To enter, complete and mail the ASTRONOMY Sweepstakes Official Entry Form bound into this magazine. Be certain that your name and address are listed correctly. You do not have to subscribe to ASTRONOMY to be eligible to win. No purchase necessary.

2. Entries are limited to one per person per month. To be eligible for monthly prize awards, entries must be postmarked by the final day of the preceding month, i.e. November 30 for the December drawing. Monthly prizes will be selected in December 1991, January 1992 and February 1992. All entries must be postmarked by January 31, 1992. The Grand Prize will be awarded in February 1992. Monthly prize winners will become ineligible for future monthly awards, but will be eligible to win the Grand Prize. All entries qualified under these rules will be eligible for the Grand Prize.

3. Winners will be selected in random drawings and decisions are final. Winners will be notified by mail and/or telephone. Any prizes returned as undeliverable will be awarded to alternate winners. Chances of winning are determined by the total number of entries received.

4. Taxes on prizes are the sole responsibility of the winners. No substitutions will be made for any prize offered. All prizes will be awarded.

5. Sweepstakes is open to residents of the U. S. and Canada. Employees and stockholders of Kalmbach Publishing Co., and their families are ineligible. Sweepstakes is subject to all Federal, State and local laws and regulations and is void where prohibited by law.

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Meetings & Events

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Astronomer for a Day program for secondary school science teachers at the American Astronomical Society meeting, Atlanta, Georgia. Contact: AAS Education Office, Department of Astronomy, University of Texas, Austin, TX 78712-1083. Phone: (512) 471-1309.

January 28 - February 2
8th Annual Winter Star Party, Camp Wesumkee, Florida Keys, Florida. Sponsored by the Southern Cross Astronomical Society. Contact: Bob or Sharon Grant, 5401 SW 110th Avenue, Miami, FL 33165. Phone: (305) 595-8778.

February 14-15
1992 European AstroFest, Royal Borough of Kensington Town Hall, England. Contact: Peter Haille and Associates Limited, Suite 75, 49 Hallam Street, London W1N 5LN. Phone: 44-71-580-2104.

May 9
Astronomy Day. Contact: Gary Tomlinson, Astronomy Day Coordinator, Public Museum of Grand Rapids, 54 Jefferson SE, Grand Rapids, MI 49503. Phone: (616) 456-3987.

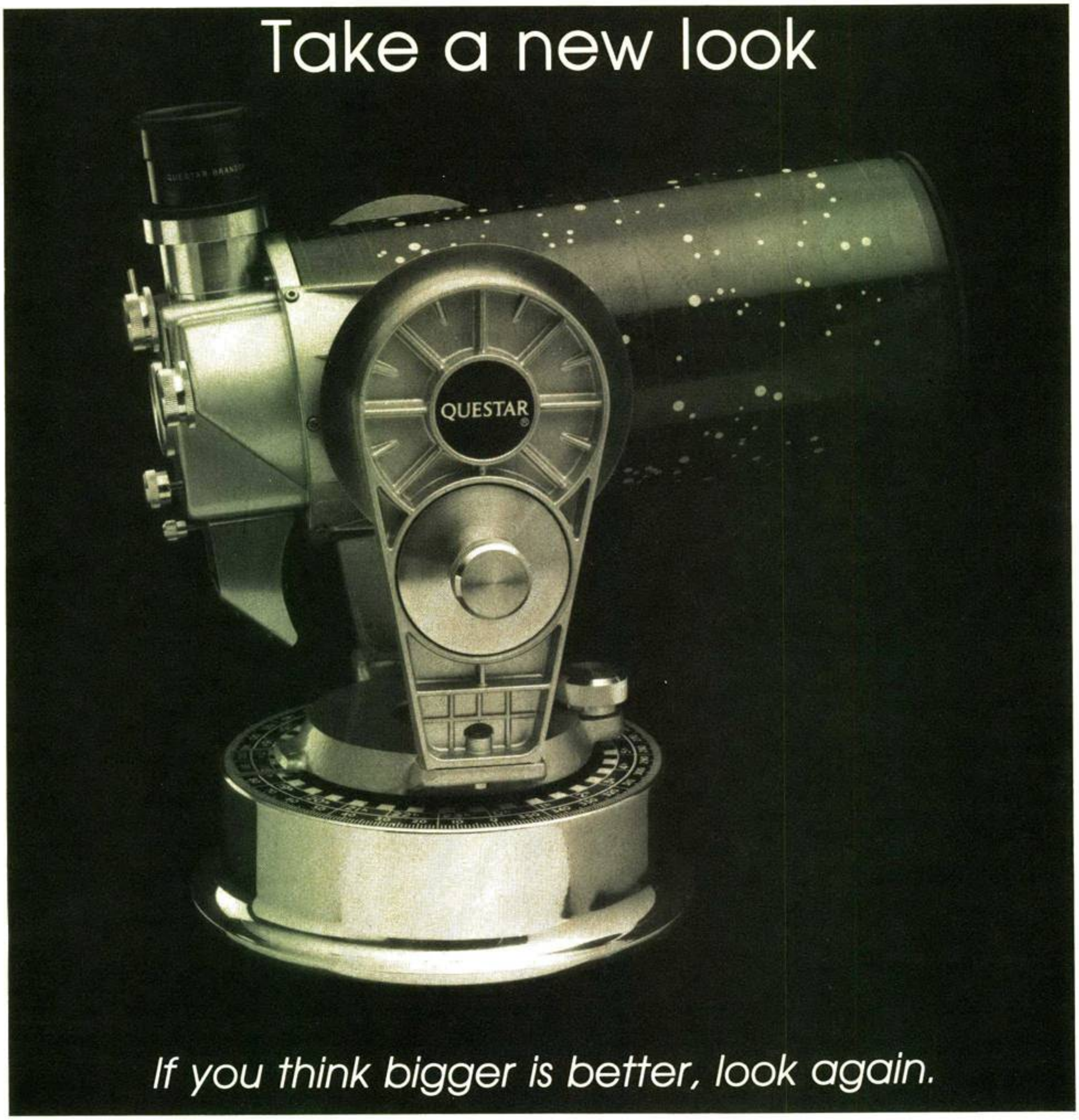
May 9
Custer Institute Family Astronomy Day, Southold, New York. Contact: Warren Hamburger at (516) 888-0072 or Barbara Lebkuecher at (516) 722-3850.

June 19-21
Astronomical League Mid-States Regional Convention, Avila College and Powell Observatory, Kansas City, Missouri. Sponsored by the Astronomical Society of Kansas City. Contact: Jackie Wade, M-S Chairman, 11305 King Street, Overland Park, KS 66210. Phone: (913) 469-0135.

September 18-21
Meeting of European (and International) Planetary and Cometary Observers, Violau, Germany. Contact: Wolfgang Meyer, Martinstrasse 1, D-(W)1000 Berlin 41, Germany. ☐

Please submit announcements at least four months before the date of the meeting or event.

When you write to organizations listed in Meetings and Events, include a self-addressed, legal-sized envelope with your request for information.



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(Required by 39 U.S.C. 3685)

1A. Title of publication: ASTRONOMY. **1B. Publication No.:** 531530.

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10. Extent and nature of circulation. 10A. Total number of copies printed (net press run): average number of copies each issue during preceding 12 months: 211,073; actual number of copies of single issue published nearest to filing date: 220,231. **10B**. Paid and/or requested circulation: **10B1.** Sales through dealers and carriers, street vendors and counter sales: 47,683; actual number of copies of single issues published nearest to filing date: 46,639. **10B2.** Mail subscription (paid and/or requested): 108,665; actual number of copies of single issues published nearest to filing date: 121,405. **10C.** Total paid and/or requested circulation (sum of 10B1 and 10B2): 156,348; actual number of copies of single issues published nearest to filing date: 168,044. **10D.** Free distribution by mail, carrier, or other means, samples, complimentary, and other free copies: 761; actual number of copies of single issues published nearest to filing date: 833. **10E.** Total distribution (sum of C and D): 157,109; actual number of copies of single issues published nearest to filing date: 168,877. **10F.** Copies not distributed: **10F1**. Office use, left over, unaccounted, spoiled after printing: 4,684; actual number of copies of single issues published nearest to filing date: 1,105. **10F2.** Return from news agents: 49,280; actual number of copies of single issues published nearest to filing date: 50,249. **10G.** Total (sum of E, F1, and F2 — should equal net press run shown in A): 211,073; actual number of copies of single issues published nearest to filing date: 220,231.

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Readings & Resources

One Day on the Sun (page 48)

The Sun by Iain Nicolson, (Mitchell Beazley Publishers, 1982). *Secrets of the Sun* by Ronald Giovanelli, (Cambridge University Press, 1984). *The Restless Sun* by Donat Wentzel, (Smithsonian Institution Press, 1989). These books describe for the lay reader the structure of the Sun, solar activity, and the Sun's interaction with Earth.

Give Your Camera a Piggyback Ride (page 76)

Observing the Constellations by John Sanford, (Simon and Schuster/Fireside, 1989). Not about astrophotography per se, but contains many piggyback photos taken by the author as part of a comprehensive constellation-by-constellation description of deep-sky objects.

1992 Sky Calendar (Special Supplement)

Observer's Handbook 1992, edited by Roy Bishop, (Royal Astronomical Society of Canada, 136 Dupont Street, Toronto, Ontario, Canada M5R 1V2). A comprehensive 230-page annual guide to celestial events. A must-have volume for many astronomers.

Astronomical Calendar 1992, edited by Guy Ottewell, (Astronomical Workshop, Furman University, Greenville, SC 29613). A large-format popular guide to the 1992 sky. Illustrated with well-executed diagrams.

CREDITS

Cover: NASA/Space Telescope Science Institute; ***p. 4:*** Paul J. Buklarewicz, taken from Hawaii on May 16; ***p. 22, bottom left:*** Dolores Hill, University of Arizona; ***bottom right:*** European Southern Observatory; ***pp. 30-31:*** Joe Bergeron; ***p. 33:*** Mike Sisk; ***pp. 38-45:*** all photos NASA; ***pp. 42-43:*** diagram by Steven Davis and Thomas L. Hunt; ***pp. 48-49:*** Ernie Piini, Celestron C-90, f/11, U-1 filter, Ektar 125 film, 2-second exposure, printing by Jacques Guertin; ***p. 50, left:*** Alan Dyer, Takahashi FC-76 refractor, f/16, Kodachrome 25 film; ***right:*** courtesy of Jack Harvey, National Solar Observatory/Tucson; ***p. 51, left:*** courtesy of Jack Harvey, National Solar Observatory/Tucson; ***right:*** courtesy of Smithsonian Astrophysical Observatory and IBM Research Division; ***pp. 52-53, center:*** courtesy Jack Streete, Rhodes College and High Altitude Observatory, 4.5-inch f/15 telescope, nonradial filter (10,000x), 27-second exposure on Kodak Technical Pan 2415 film; ***top left, left center, top right, bottom right:*** courtesy of Jack Harvey, National Solar Observatory/Tucson; ***bottom left:*** courtesy of Lou Gilliam, National Solar Observatory/Sacramento Peak; ***p. 54, top:*** line art by Patrick McIntosh, NOAA/SEL; ***bottom:*** Michael Stecker, 400mm f/11 lens, Ektar 125 film; ***p. 60:*** Jim Rostirolla, 300mm lens, Kodachrome 25, July 21, 1990, from Deception Pass, Washington; ***p. 63:*** Bob Burt, July 11, 1991; ***p. 76:*** John Sanford, 15mm lens at f/4, 10-minute exposure, Ektapress 1600; ***p. 77:*** John Sanford; ***p. 78, top:*** Chris Schur, 50mm lens at f/2.8, 60-minute exposure, hypered Fujichrome 100; ***p. 78, bottom:*** Lill Nelson, 280mm lens at f/2.8, 20-minute exposure, hypered Ektachrome 200; ***p. 79:*** Jack Marling, 135mm lens at f/2.8, 25-minute exposure, Fujichrome 400 with a Deep-Sky filter; ***p. 80, top* left:** Chris Floyd, 35mm lens at f/3.6, 55-minute exposure, ISO 200 film; ***p. 80, top right:*** John Sanford, 50mm lens at f/2.8, 15-minute exposure, Ilford XP-1 film; ***p. 80, bottom:*** John Sanford, Pentax 6x7 camera with a 45mm lens at f/4.5, 15-minute exposure, Konica 3200, ***p. 81:*** John Sanford; ***p. 83:*** Alan French; ***pp. 84-86:*** Jim Phillips; ***p. 89, top:*** Paul A. Smith, 6-inch f/6 reflector at 150x and 200x on January 1, 1991; ***bottom left:*** Randy Pakan, 16-inch f/5 reflector at 285x on May 3, 1991; ***bottom right:*** Gregory Terrance, 16-inch reflector at f/84, Tech Pan film, 1-second exposure; ***p. 90, top left:*** Kim Zussman, 14.5-inch f/8 Cassegrain, hypersensitized Tech Pan film, 180-minute exposure; ***bottom left:*** L. Allen Beers, 50mm f/1.7 lens, Fujichrome HG 1600 film, 90-second exposure; ***top right:*** Gordon Garcia, 4.7-inch refractor at f/79, Tech Pan film, 1/1000-second exposure with aluminized mylar filter; ***bottom right:*** Marco Milani; ***p. 91:*** Michael Stecker, 180mm f/2.5 lens, hypersensitized Tech Pan film, 70-minute exposure with a hydrogen-alpha filter; ***Sky Calendar Supplement Cover:*** Moon, Venus, Mars, and Jupiter by Tom Ritland, June 15, 1991, 35mm lens at f/2, Ektachrome 100; ***Summer Sky**:* Wide-field Sagittarius by Father Ronald Royer; M17 by Chris Schur, 16″ f/4.5, 30 minutes, hypered Konica 1600, Deep-Sky filter; M22 by Jack Newton, 20″ f/5, 8 minutes, Konica 3200 with medium-format cold camera; M8 by Scott Hicks, 12.5″ f/4.8, 23 minutes, Konica 1600; M7 by Brad Wallis, 6″ f/6, 20 minutes, GAF 200 film; ***Winter Sky:*** Wide-field Orion by Father Ronald Royer; M78 by Jack Newton, 16″ f/5, 15 minutes; Horsehead Region by Michael Stecker, Takahashi 8″ f/4 hyperbolic astrograph, 25 minutes, hypered Konica 3200; M42 by John Gleason, 8″ Schmidt-Cassegrain at f/10, 60 minutes, High Speed Ektachrome; ***January:*** Crescent Moon near Venus by Martin Hale, April 1986, Celestron 6″ f/5 reflector, 2 seconds, ISO 1600 film; ***March:*** Jupiter sketch by Edwin Faughn, Jan. 17, 1991, 10″ f/10 SCT; ***May:*** Pluto photos courtesy Lick Observatory; ***June:*** Partial lunar eclipse by Ivan Dryer; ***August:*** Twilight planets by John Thielen, taken from Top Lake, Desolation Wilderness, California, June 15, 1991, 28mm lens at f/2.8, 1 second, Ektachrome 400; ***September:*** original CCD images of Saturn by Don Parker, image processing and color compositing by Richard Berry using ImagePro software; ***November:*** Mars photo by Don Parker; ***December:*** Feb. 9, 1990 lunar eclipse by Lauri Mala, Finland, 10″ Meade LX-6 telescope and Olympus OM2N camera on auto-exposure.

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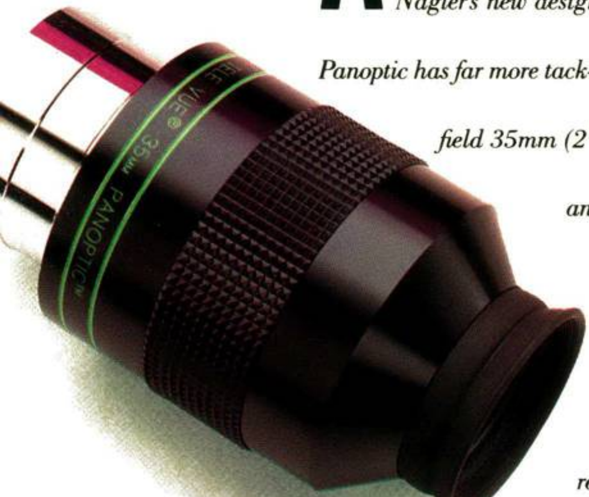

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Cll photo by Jim Riffle, Cloudcroft, NM. 5-minute exposure using Konica 3200 film at f/6.3

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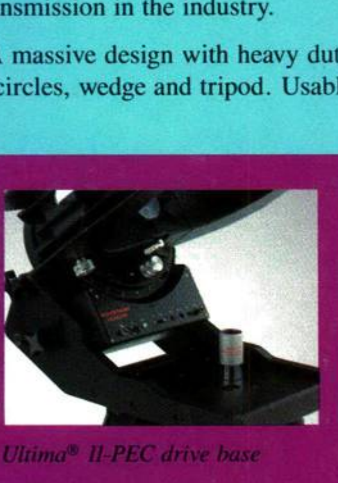

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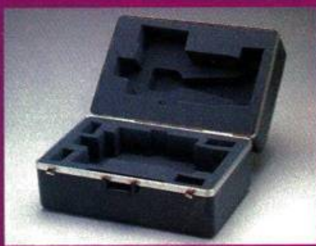

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1992 Sky Calendar

Supplement to
ASTRONOMY
Magazine

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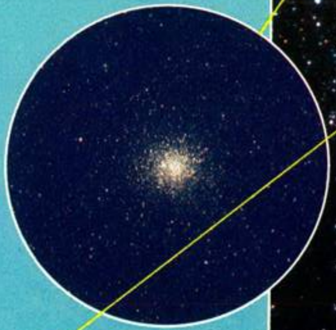
SAGITTARIUS IN SUMMER

Our calendar highlights the best celestial events for each month in 1992. All involve objects in the solar system — the Sun, Moon, and planets. But some of the sky's best sights are "deep-sky" objects — star clusters, nebulae, and galaxies.

During the summer the richest hunting ground for binoculars or a small telescope is the starfields of Sagittarius. For northern latitudes, this constellation skims the southern horizon during June to September evenings. Look for a pattern of stars that looks like a teapot. Scan above and to the west of the teapot's spout, and you'll discover many deep-sky objects, including the ones pictured below. All are located within the Milky Way and lie toward the center of our Galaxy. (Wide-field photo at right by Ronald Royer.)

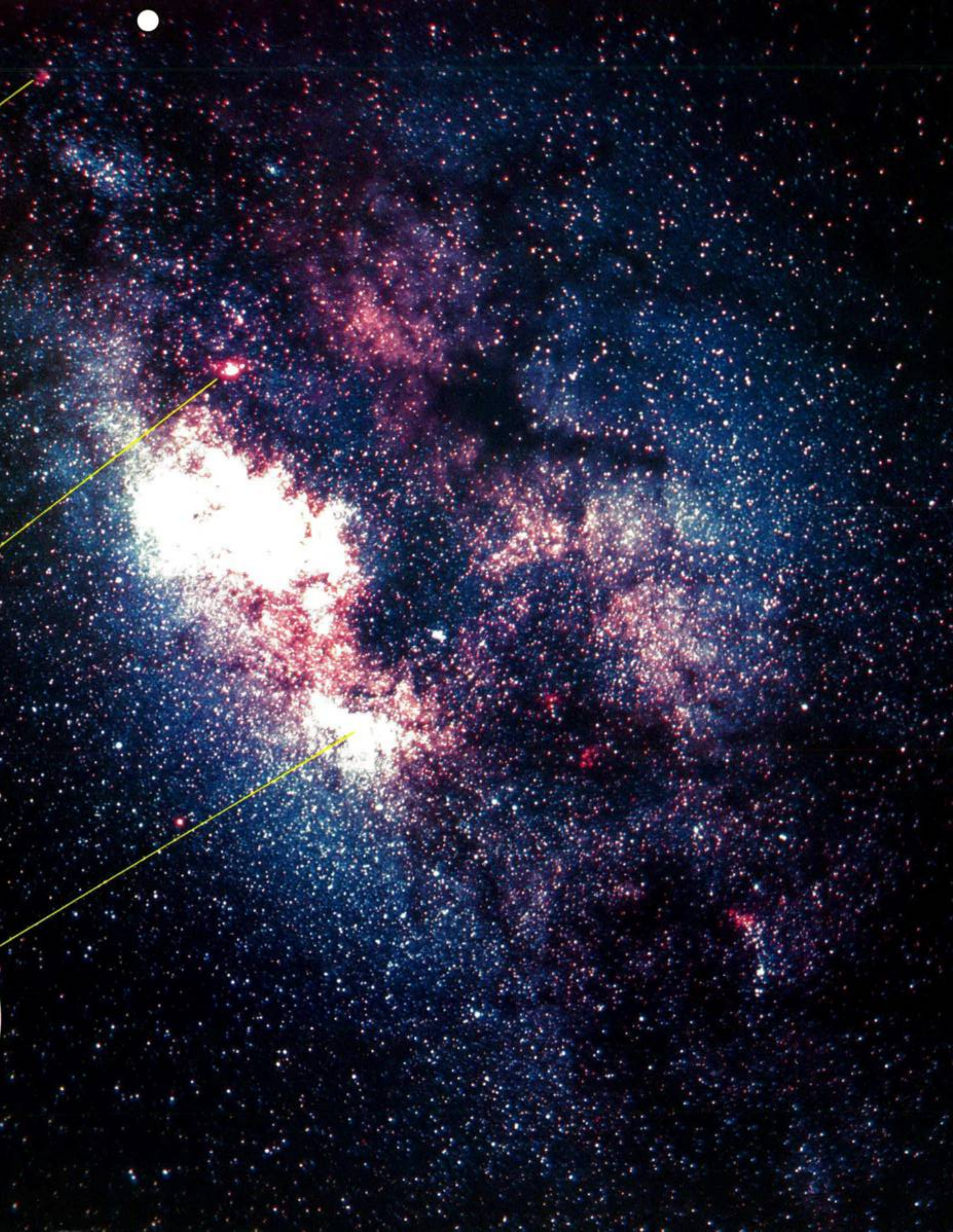
Swan Nebula (M17)
Distance = 3,000 light-years
Photo by Chris Schur



Globular Cluster M22
Distance = 10,000 light-years
Photo by Jack Newton

Lagoon Nebula (M8)
Distance = 4,500 light-years
Photo by Scott Hicks

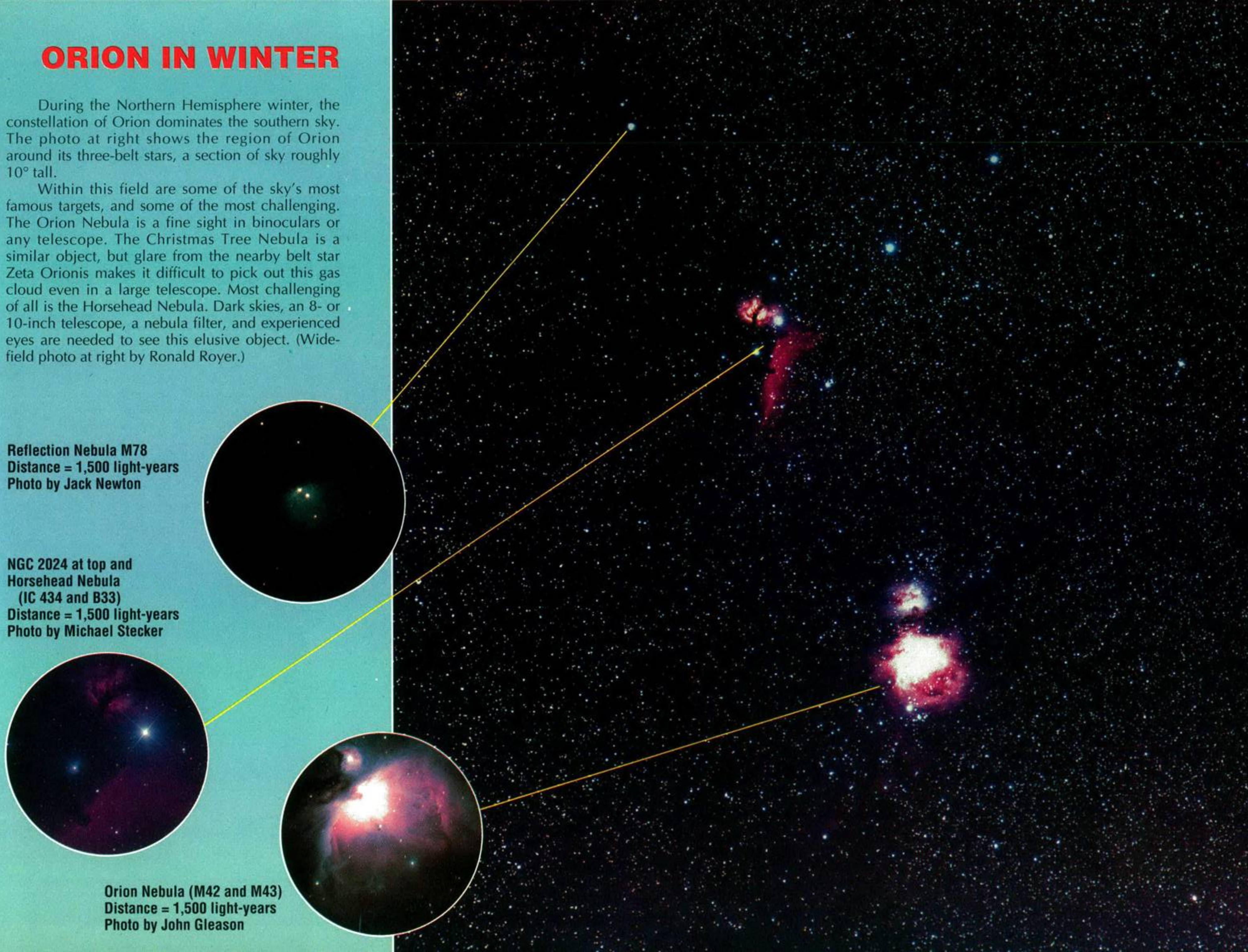
Open Cluster M7
Distance = 800 light-years
Photo by Brad Wallis



ORION IN WINTER

During the Northern Hemisphere winter, the constellation of Orion dominates the southern sky. The photo at right shows the region of Orion around its three-belt stars, a section of sky roughly 10° tall.

Within this field are some of the sky's most famous targets, and some of the most challenging. The Orion Nebula is a fine sight in binoculars or any telescope. The Christmas Tree Nebula is a similar object, but glare from the nearby belt star Zeta Orionis makes it difficult to pick out this gas cloud even in a large telescope. Most challenging of all is the Horsehead Nebula. Dark skies, an 8- or 10-inch telescope, a nebula filter, and experienced eyes are needed to see this elusive object. (Wide-field photo at right by Ronald Royer.)



Reflection Nebula M78
Distance = 1,500 light-years
Photo by Jack Newton

NGC 2024 at top and
Horsehead Nebula
(IC 434 and B33)
Distance = 1,500 light-years
Photo by Michael Stecker

Orion Nebula (M42 and M43)
Distance = 1,500 light-years
Photo by John Gleason

JANUARY

			1	2	3	4 ●
5	6	7	8	9	10	11
12	13 ◐	14	15	16	17	18
19 ○	20	21	22	23	24	25
26 ◑	27	28	29	30	31	

JANUARY

Day	Hour (UT)	
1	12	**Venus 5° N. of crescent Moon (morning)**
3	1	**Mercury 3° N. of crescent Moon (morning)**
	10	**Mars 0.8° N. of crescent Moon (morning)**
	15	Earth at perihelion (closest to Sun)
4	12	Quadrantid meteors peak (New Moon)
	23	**Annular eclipse of Sun (Pacific, S. California)**
6	23	Saturn 3° S. of Moon (low in western evening)
7	23	Asteroid Juno 0.2° S. of Moon (evening)
10	20	**Mercury 0.6° N. of Mars (morning)**
19	21	**Closest Full Moon of 1992 (351,900 km)**
20	10	Mars 0.06° N. of M22 globular cluster
29	21	Mars 0.4° S. of Uranus (morning)
	22	Saturn in conjunction (behind Sun)
31	17	**Venus 1° N. of crescent Moon in Sagittarius**

Events in **bold** are good astrophotography targets.

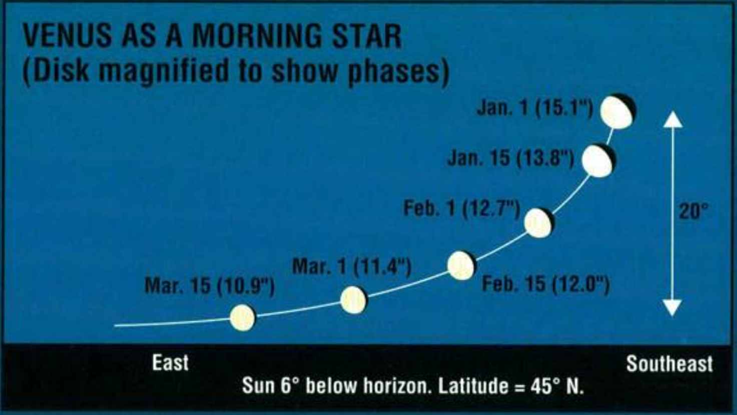
NOTE: Dark sky observing windows are indicated by the blue shading on the calendars for each month. At First Quarter Moon, the sky is dark during the last half of the night after moonset. At Last Quarter, the sky is dark during the first half of the night before moonrise.

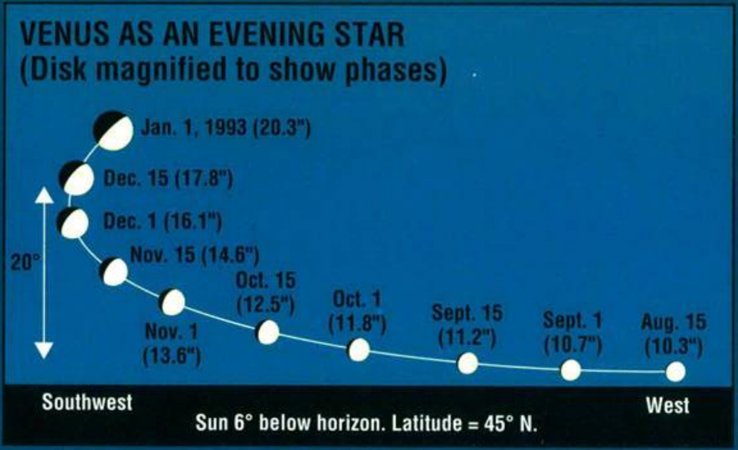
VENUS BLAZES IN THE EAST

The first event of 1992 is a close passage of the crescent Moon past Venus on New Year's morning. The crescent Moon near brilliant Venus is always a striking sight. These close approaches occur monthly in the morning sky from January to April and then in the evening sky from August to December.

As 1992 opens, Venus is a bright magnitude –4.1 "morning star" in the southeast dawn sky. Its peak brilliance and altitude occurred in late 1991; through late winter and early spring of '92, Venus descends closer to the horizon each morning. Through a telescope its disk shrinks and its phase turns from gibbous to nearly full as Venus recedes from Earth and disappears behind the Sun. (The numbers next to the dates on the diagrams below indicate the size of the disk in arcseconds.)

Venus becomes lost in the Sun's glare from mid-April to early August. In the summer, it emerges from behind the Sun and begins to climb into the evening sky in the west. But unlike its 1991 evening apparition, Venus never gets far above the western horizon this year.


VENUS AS A MORNING STAR
(Disk magnified to show phases)
Jan. 1 (15.1")
Jan. 15 (13.8")
Feb. 1 (12.7")
Feb. 15 (12.0")
Mar. 1 (11.4")
Mar. 15 (10.9")
20°
East
Southeast
Sun 6° below horizon. Latitude = 45° N.


VENUS AS AN EVENING STAR
(Disk magnified to show phases)
Jan. 1, 1993 (20.3")
Dec. 15 (17.8")
Dec. 1 (16.1")
Nov. 15 (14.6")
Nov. 1 (13.6")
Oct. 15 (12.5")
Oct. 1 (11.8")
Sept. 15 (11.2")
Sept. 1 (10.7")
Aug. 15 (10.3")
20°
Southwest
West
Sun 6° below horizon. Latitude = 45° N.

THE CRESCENT MOON NEAR VENUS will be an attractive monthly sight in the morning sky until April and then in the evening sky from August until December. Photo by Martin Hale.

FEBRUARY						
						1
2	3 ●	4	5	6	7	8
9	10	11 ◑	12	13	14	15
16	17	18 ○	19	20	21	22
23	24	25 ◐	26	27	28	29

FEBRUARY

Day	Hour (UT)	
1	8	**Mars 1.5° S. of Neptune**
	9	Occultation of Uranus (Europe, Britain)
	12	Occultation of Neptune (S. America, Africa)
	13	**Mars 1.5° S. of crescent Moon**
7	7	Venus 0.9° N. of Uranus
8	15	Venus 0.3° S. of Neptune
12	6	**First Quarter Moon 1° S. of Pleiades**
16	23	**Close grouping of Io, Europa, & Callisto**
19	7	Jupiter 6° N. of nearly Full Moon
	22	**Venus 0.9° N. of Mars (morning)**
28	21	Occultation of Neptune (Pacific)
29	1	Jupiter at opposition (rises at sunset)
	2	**Venus 0.1° N. of Saturn (morning)**
	—	LEAP DAY!

Events in **bold** are good astrophotography targets.

THREE PLANETS CLUSTER IN THE MORNING

Venus is not the only planet in the morning during early 1992. In fact, there is a planetary traffic jam going on in the dawn sky through late February and early March. The parties involved are Venus, Mars, and Saturn.

February starts out with Mars in the middle of the trio. Venus is above it going down toward the horizon while Saturn is below Mars headed up. Venus reaches Mars first. On the mornings of February 19 and 20 (for North America) Venus is about a degree away from the Red Planet. Venus then drops below Mars and descends to meet Saturn. On the morning of the 28th and 29th (depicted below), Venus is within $\frac{1}{2}$° of Saturn, forming one of the best planetary conjunctions of the year. The crescent Moon is just above the three planets.

On the next two mornings, March 1 and 2, Venus and Saturn are farther apart but the crescent Moon is closest to the cluster of planets. If you missed the great triple planet conjunction of June 1991, this is the next best thing. The interplanetary passing game ends on the morning of March 6 when Saturn reaches Mars. Through the remainder of March, Saturn pulls up away from Mars and Venus drops down toward the Sun, breaking the cluster apart.

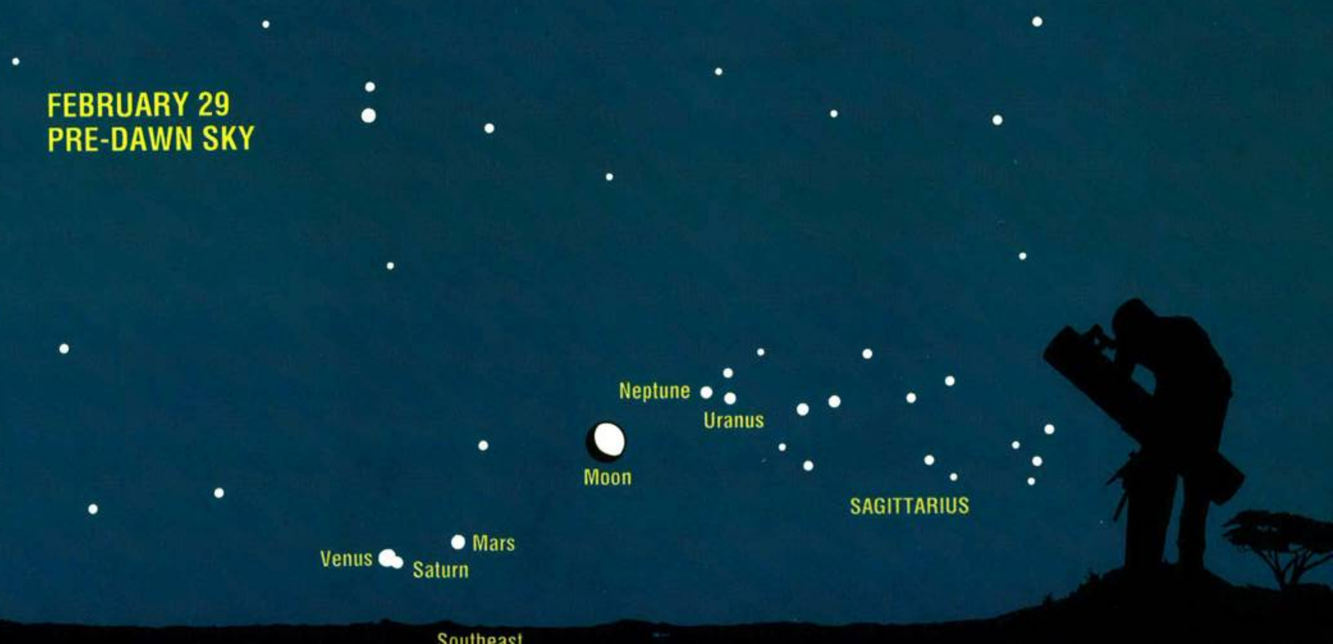
WHAT'S UT?

When giving times for a celestial event that will be visible over a large geographic area, astronomers use Coordinated Universal Time, abbreviated UTC or just UT. This is the standard time at Greenwich, England, given in the 24-hour style (4 p.m. = 16:00). To find out the time in your time zone subtract the appropriate number of hours:

North American Time Zone	Standard Time	Daylight Saving
Atlantic	−4	−3
Eastern	−5	−4
Central	−6	−5
Mountain	−7	−6
Pacific	−8	−7
Alaska	−9	−8
Hawaii	−10	—

Watch your dates when converting! For example, a time given as 4 hours UT on June 15 will convert to 11 p.m. Central Daylight Time on the 14th. Don't miss an event because for your time zone it occurred the evening before the listed date!

FEBRUARY 29
PRE-DAWN SKY



MARCH

1	2	3	4 ●	5	6	7
8	9	10	11	12 ◐	13	14
15	16	17	18 ○	19	20	21
22	23	24	25	26 ◑	27	28
29	30	31				

MARCH

Day	Hour (UT)	
1	18	**Mars 4° S. of crescent Moon (morning)**
2	1	**Saturn 4° S. of crescent Moon (morning)**
	6	**Venus 4° S. of crescent Moon (morning)**
5	—	**Look for very young moon in west**
6	6	**Mercury 4° S. of crescent Moon (evening)**
	13	**Mars 0.4° S. of Saturn (morning)**
9	4	Asteroid Vesta at opposition
	21	**Mercury at greatest elong. E. (evening)** *(best evening appearance for northern latitudes)*
	—	Saturn 0.1° S. of Theta Capricornus
10	11	**First Quarter Moon 2° S. of Pleiades (Asia)**
17	12	Jupiter 6° N. of nearly Full Moon
20	9	Vernal equinox (spring begins)
27	5	Occultation of Neptune (Africa, Asia)
29	14	Saturn 4° S. of crescent Moon (morning)
31	1	Mars 6° S. of crescent Moon (morning)

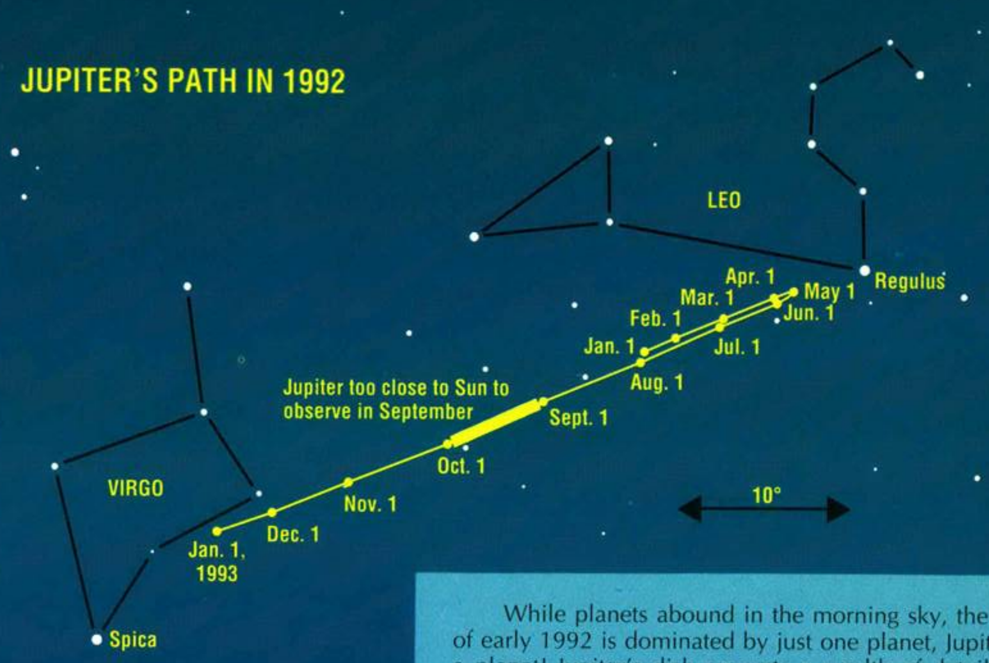
Events in **bold** are good astrophotography targets.

DATES FOR THIN CRESCENT MOON

Mar. 5	Age = 33.5 hours
Apr. 3	Age = 18.5 hours
May 3	Age = 30 hours (Moon 2° S. of Pleiades)
Jun. 1	Age = 20 hours

JUPITER DOMINATES THE EVENING SKY

JUPITER'S PATH IN 1992



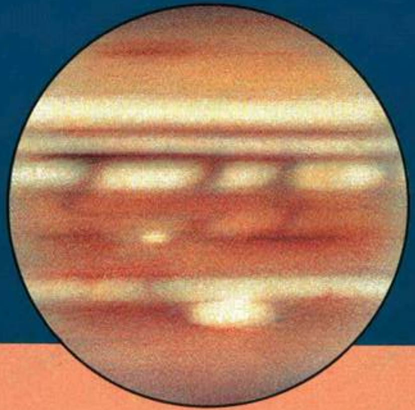
While planets abound in the morning sky, the evening sky of early 1992 is dominated by just one planet, Jupiter. But what a planet! Jupiter's disk presents a wealth of detail to examine through a telescope.

Jupiter reached opposition on Leap Day, February 29. On that night Jupiter was directly opposite the Sun and rose in the east as the Sun set in the west. Each night Jupiter rises a little bit earlier, so by April and through the rest of the spring Jupiter is well up in the east as it gets dark.

Jupiter spends the first half of the year looping below the stars of Leo. The giant planet is conveniently placed in the evening sky until August. It then disappears behind the Sun in September. When it emerges in the morning sky in October, Jupiter will have made the move into Virgo where it spends the rest of 1992 and most of 1993.

SEEING THE EARLIEST MOON

A popular challenge of recent years has been sighting the earliest sliver of the crescent Moon in the evening sky. For North America, March 5, April 3, May 3 (when it is also near the Pleiades), and June 1 are good nights to look. The exact age of the Moon will vary depending on when you look and where you look from. The age we have indicated at left is for New York City at sunset. From locations farther west in North America, the Moon will have "aged" some more by the time sunset reaches your location.



JUPITER'S CLOUDS are a fascinating sight when viewed under steady seeing conditions. On January 17, 1991, Edwin Faughn sketched Jupiter's banded appearance through a 10-inch f/10 Schmidt-Cassegrain telescope.

APRIL						
			1	2	3 ●	4
5	6	7	8	9	10 ◑	11
12	13	14	15	16	17 ○	18
19	20	21	22	23	24 ◐	25
26	27	28	29	30		

APRIL

Day	Hour (UT)	
1	19	**Venus 7° S. of crescent Moon (morning)**
2	8	**Mercury 4° S. of crescent Moon (morning)**
3	—	**Look for very young Moon in west**
5	23	**Mercury 2° N. of Venus (morning)**
	—	Daylight Saving Time begins
6	15	**Crescent Moon 2° S. of Pleiades (Europe)**
13	16	Jupiter 6° N. of gibbous Moon (evening)
21	21	Lyrid meteors (waning gibbous Moon)
23	14	Occultation of Neptune (N. America)
	15	**Mercury at greatest elong. W. (morning)**
26	2	Saturn 5° S. of crescent Moon (morning)
29	7	Mars 7° S. of crescent Moon (morning)
30	21	Mercury 8° S. of crescent Moon (morning)

Events in **bold** are good astrophotography targets.

MERCURY APPEARS IN THE SPRING SKY

Springtime is the best chance to nab elusive Mercury during one of its brief appearances above the horizon. In the spring, Mercury's path across the evening sky is steeply angled with respect to the western horizon. This helps bring Mercury higher in the sky than it otherwise would be. This year, the best evening appearance of Mercury (at least for northern latitude observers) is in early March. As shown below, over the three-week apparition, Mercury changes from a small, fully illuminated disk to a larger, thin crescent. But you need a telescope to pick out these phases. At greatest elongation on March 9 scan with binoculars for a −0.4-magnitude star low in the twilight glow. Other good dates to look for Mercury are March 5 or March 6 when it is close to the very thin crescent Moon.

In April, Mercury zips over into the morning sky. On April 5 and 6 it is within 3° of Venus, but the duo skims the eastern horizon. Mercury then climbs higher and reaches greatest elongation from the Sun on April 23, but even then Mercury is only 5° to 7° above the horizon at sunrise (for northern latitudes).

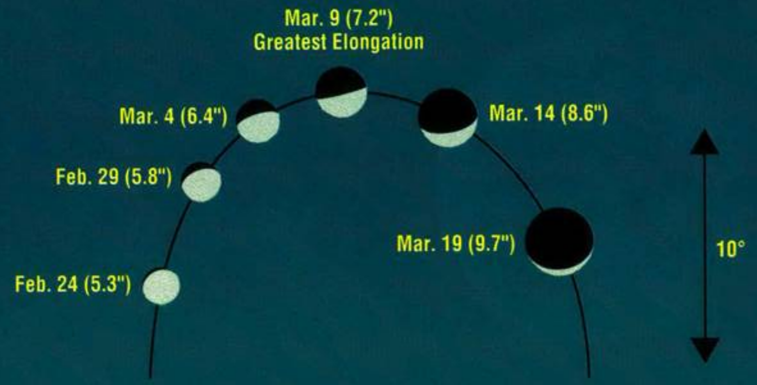
SEEING SEVEN PLANETS AT ONCE

When Mercury comes above the horizon in April, it joins Venus, Mars, and Saturn in the east. At the same time, Uranus and Neptune are nearby in Sagittarius, while Pluto is farther to the west in Serpens, giving early risers with telescopes a chance to see seven planets strung across the morning sky. Only Jupiter is missing from the gathering. It is in the west in the April predawn hours but sets before Mercury and Venus rise.

WHEN TO SEE MERCURY IN 1992

Evening Elongations			Morning Elongations		
Gr. Elong.	Visible During . . .	Max. Angle From Sun	Gr. Elong.	Visible During . . .	Max. Angle From Sun
Mar. 9	Feb. 23 – Mar. 19	18° (best)	Apr. 23	Apr. 3 – May 24	27°
July 6	June 8 – July 26	26°	Aug. 21	Aug. 11 – Sept. 6	18° (best)
Oct. 31	Sept. 27 – Nov. 16	24°	Dec. 9	Nov. 28 – Dec. 31	21°

MERCURY AS A SPRING EVENING STAR
(Disk magnified to show phases)



MAY						
					1	2 ●
3	4	5	6	7	8	9 ◐
10	11	12	13	14	15	16 ○
17	18	19	20	21	22	23
24 ◑ 31	25	26	27	28	29	30

MAY

Day	Hour (UT)	
1	5	Jupiter stationary
4	1	**Young Moon 2° S. of Pleiades (N. America, evening of May 3)**
	20	Eta Aquarid meteors (waxing crescent Moon)
10	22	Jupiter 6° N. of First Quarter Moon
12	1	**Pluto at opposition (rises at sunset)**
20	21	Occultation of Neptune (Asia)
23	12	Saturn 5° S. of Last Quarter Moon (morning)
28	9	Mars 7° S. of crescent Moon (morning)

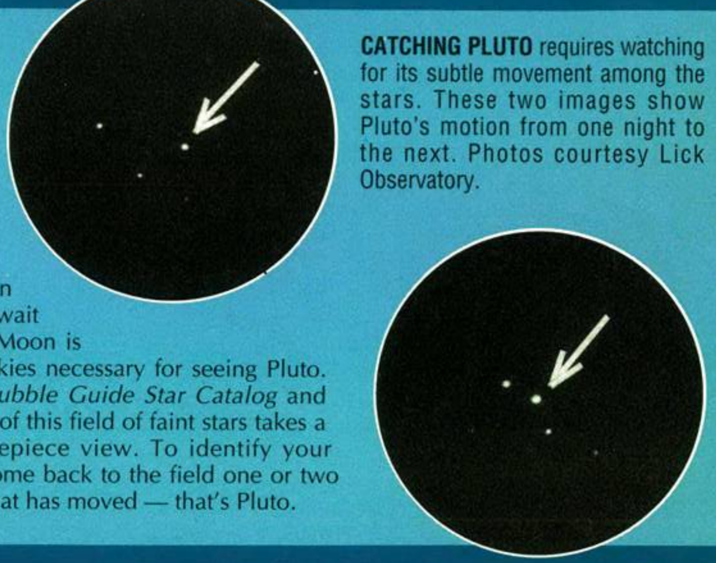
Events in **bold** are good astrophotography targets.

WHAT'S A MAGNITUDE?

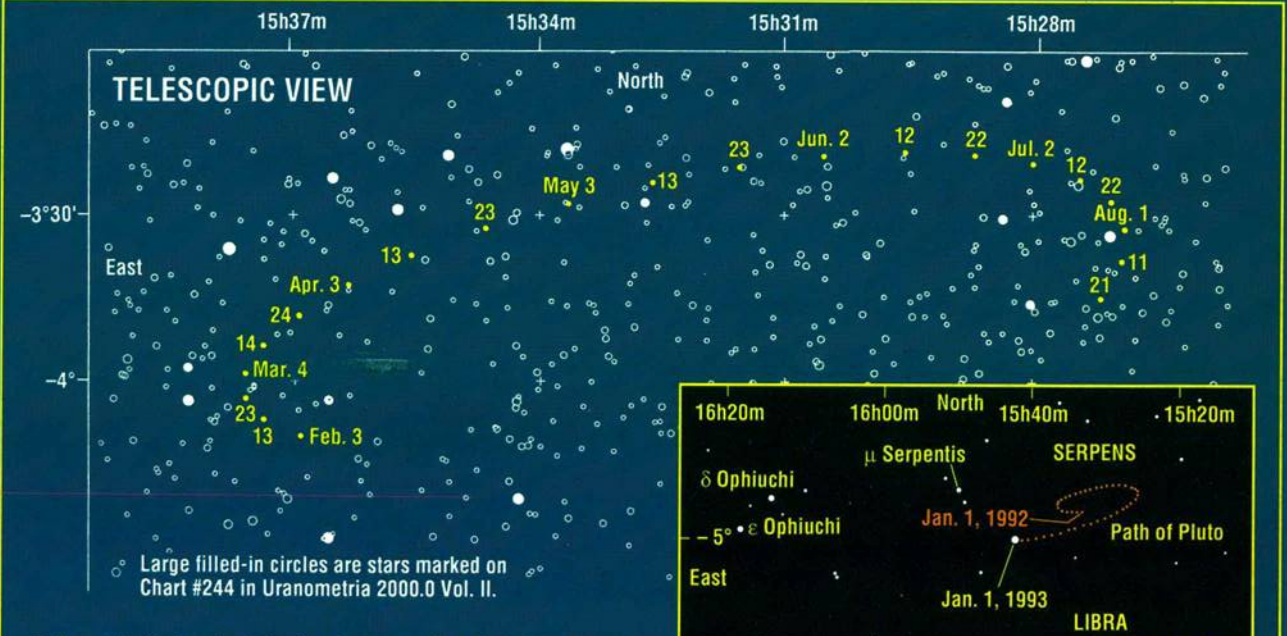
The brightness of a celestial object is called its "magnitude." The magnitude scale works backward from what you might expect: stars with a high magnitude number, say 9, appear fainter than stars with a magnitude of 1. The faintest stars you can see with the unaided eye are magnitude 6 to 7. A 4-inch aperture telescope can show stars as faint as magnitude 12.5, while the greater light-gathering power of a 12-inch scope can reach down to magnitude 15. At the other end of the scale, the brightest stars typically shine at magnitude 1, with a few of the brightest assigned a magnitude of 0 or –1. Planets can be brighter still: Jupiter shines at –2.5 this February and March while Venus will reach –4.3 in December.

PLUTO AT ITS BEST

Pluto spends 1992 looping through a small section of sky on the Serpens-Libra border. May is a good month to track down the faintest planet — this is the month Pluto reaches opposition and is closest to Earth and therefore brightest. The actual night of opposition is May 11/12. Pluto is then at magnitude 13.7, within the light-gathering ability of an 8-inch telescope. But for a night of Pluto hunting, you're better off selecting an evening in the first week of May or late April, or wait until late May or early June. At those times the Moon is out of the sky, essential for providing the dark skies necessary for seeing Pluto. The telescopic chart below is based on the *Hubble Guide Star Catalog* and shows stars to magnitude 14.7. Picking Pluto out of this field of faint stars takes a careful comparison of the chart with your eyepiece view. To identify your suspect, make a drawing of the field and then come back to the field one or two nights later. You should be able to find one star that has moved — that's Pluto.



CATCHING PLUTO requires watching for its subtle movement among the stars. These two images show Pluto's motion from one night to the next. Photos courtesy Lick Observatory.



Large filled-in circles are stars marked on Chart #244 in Uranometria 2000.0 Vol. II.

Telescopic finder chart by Ian Cameron, Lockhart Planetarium (Winnipeg, Manitoba) and courtesy the *Observer's Handbook* of the Royal Astronomical Society of Canada.

JUNE						
	1 ●	2	3	4	5	6
7 ◐	8	9	10	11	12	13
14	15 ○	16	17	18	19	20
21	22	23 ◑	24	25	26	27
28	29	30 ●				

JUNE

Day	Hour (UT)	
1	—	**Look for young Moon in west**
7	7	Jupiter 7° N. of First Quarter Moon
13	16	Venus in superior conjunction (behind Sun)
15	5	**Partial eclipse of the Moon (N. America)**
17	4	Occultation of Neptune (Europe)
18	23	Asteroid Pallas at opposition
19	19	Saturn 5° S. of Moon (morning)
20	20	**Close grouping of Io, Europa, and Callisto**
21	3	Summer solstice (summer begins)
23	2	Mercury 5° S. of Pollux in Gemini (evening)
26	8	Mars 6° S of crescent Moon (morning)
30	12	**Total eclipse of the Sun (South Atlantic)**

Events in **bold** are good astrophotography targets.

MOON ENCOUNTERS EARTH'S SHADOW

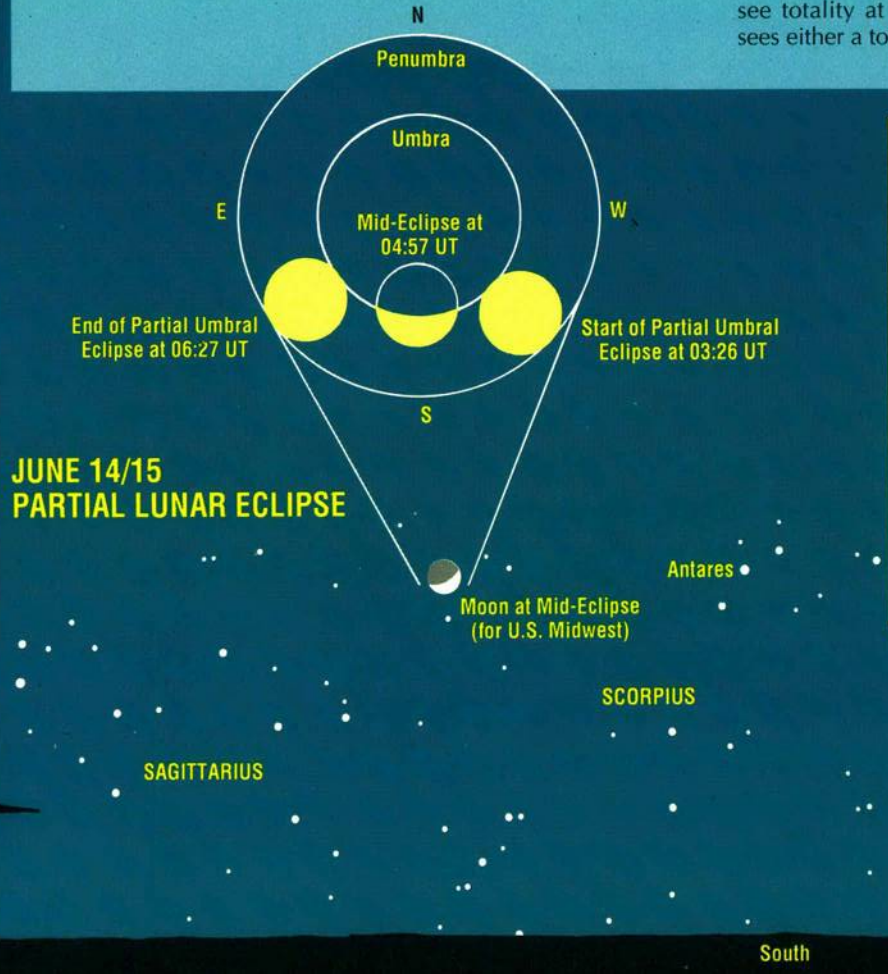
For North American skywatchers, the big events of 1992 are the two eclipses of the Moon. The first occurs on the night of June 14/15. It's only a partial eclipse but a substantial partial — at mid-eclipse, 68 percent of the disk of the Full Moon is immersed in the umbra, the darkest part of Earth's shadow. This should be sufficient to make the darkened two-thirds of the Moon look distinctly red, a highlight of lunar eclipses.

You won't see much evidence that the eclipse is in progress until the Moon starts to enter the umbra. This occurs on June 14 at 11:26 p.m. Eastern Daylight Time (10:26 p.m. Central, 9:26 p.m. Mountain). For eastern North America, mid-eclipse occurs after midnight (making it June 15) at 12:57 a.m. EDT. The umbral phase of the eclipse ends at 2:27 a.m. EDT (1:27 a.m. Central, 12:27 a.m. Mountain, 11:27 p.m. Pacific).

Most of North America gets to see this eclipse. However, for the Pacific Northwest and western Canada, the Moon rises with the umbral phase already in progress. Only Alaska and the Yukon miss most of this eclipse.

TOTAL ECLIPSE OF THE SUN

The path of totality for the June 30 solar eclipse travels across the cloudy and stormy South Atlantic. The best prospects for seeing this eclipse are from an aircraft. The only land the path touches is the west coast of Uruguay and extreme southern Brazil where eclipse watchers will see totality at sunrise. No part of North America sees either a total or partial eclipse June 30.


N
Penumbra
Umbra
E
W
Mid-Eclipse at 04:57 UT
End of Partial Umbral Eclipse at 06:27 UT
Start of Partial Umbral Eclipse at 03:26 UT
S
Moon at Mid-Eclipse (for U.S. Midwest)
Antares
SCORPIUS
SAGITTARIUS
South

JUNE 14/15
PARTIAL LUNAR ECLIPSE

THE DARK SHADOW OF EARTH will cross the northern two-thirds of the Full Moon on the night June 14/15, creating a sight similar to this view of the June 25, 1983 partial lunar eclipse captured by Ivan Dryer.

JULY						
			1	2	3	4
5	6	7 ◐	8	9	10	11
12	13	14 ○	15	16	17	18
19	20	21	22 ◑	23	24	25
26	27	28	29 ●	30	31	

JULY

Day	Hour (UT)	
2	10	**Mercury 4° N. of Moon (evening)**
3	12	Earth at aphelion (farthest from Sun)
4	20	**Jupiter 7° N. of crescent Moon (evening)**
6	1	Mercury at greatest elong. E. (evening)
7	23	Uranus at opposition (rises at sunset)
9	13	Neptune at opposition (rises at sunset)
14	6	Uranus 1.8° S. of Full Moon
	9	Occultation of Neptune (Pacific)
	19	**Farthest Full Moon of 1992 (402,600 km)**
16	23	Saturn 5° S. of Moon
25	4	**Mars 4° S. of Moon & near Pleiades**
	15	Mercury 6° S. of Venus (low in west)
	22	Asteroid Ceres at opposition
28	11	Delta Aquarid meteors peak (New Moon)

Events in **bold** are good astrophotography targets.

TWO DISTANT PLANETS TOGETHER

Uranus and Neptune are traditionally described as twin planets. They are nearly the same size and are both blue-green gas giants near the edge of the solar system. But in the 1980s, Voyager 2 found that these two "twins" are not so identical: Uranus is bland in appearance and lacks the active weather systems that dot the atmosphere of Neptune.

Nevertheless, in the minds of backyard astronomers, these two planets are still twins — both appear as tiny blue-green disks, with little or no cloud features visible even at high power under the steadiest of seeing conditions. This year, these two worlds take on an even closer affiliation. For most of 1992, Uranus and Neptune are only 2° to 3° apart, sharing the same patch of sky in northern Sagittarius and traveling almost parallel paths. (The two planets are closest together in April and May.)

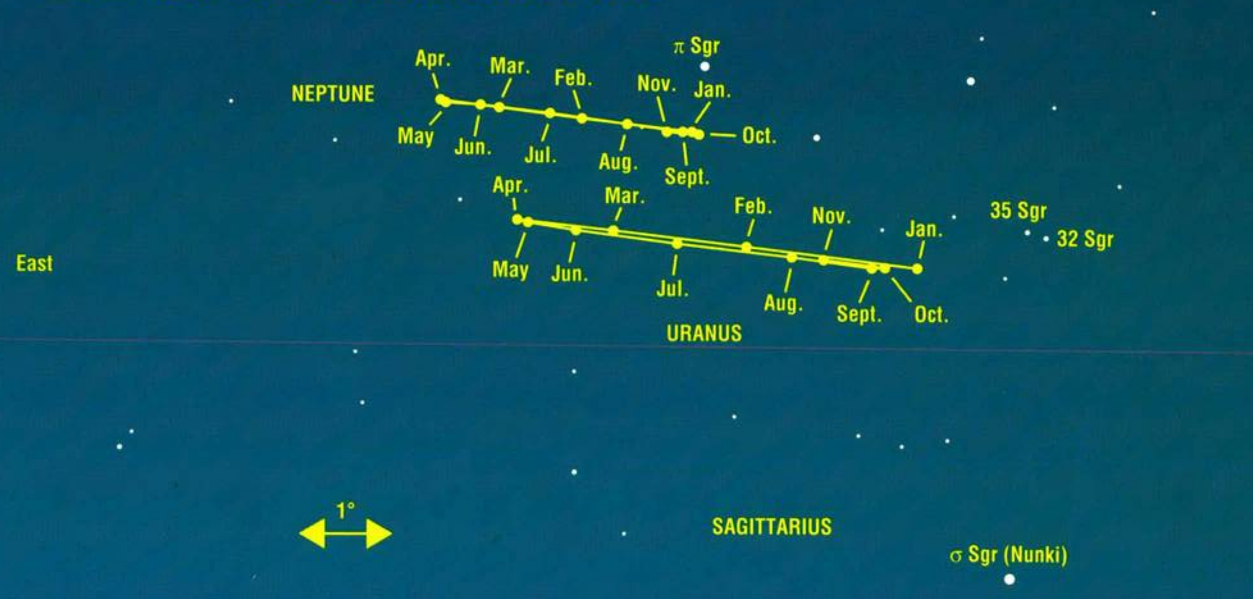
Uranus reaches opposition on July 7 when its 3.8-arcsecond disk will shine at magnitude 5.6, just visible to the unaided eye and an easy binocular object. Neptune reaches opposition two days later. At magnitude 7.9 and with a disk only 2.3 arcseconds across, Neptune requires a telescope to pick out.

METEOR SHOWERS IN 1992

Summer is usually the best time for seeing meteors. Unfortunately, the best summer meteor shower, the Perseids, is washed out this year by the Full Moon.

Shower	Date	Rate (#/hr)	Viewing Conditions
Quadrantid	Jan. 4	60	Good
Lyrid	Apr. 21	10	Fair
η Aquarid	May 4	35	Good
δ Aquarid	July 28	20	Good
Perseid	Aug. 12	75	Poor
Draconids	Oct. 8	?	Poor
Orionid	Oct. 21	25	Good
S. Taurid	Nov. 2	10	Fair
Leonid	Nov. 17	10	Fair
Geminid	Dec. 13	75	Fair
Ursid	Dec. 23	5	Good

THE PATHS OF URANUS AND NEPTUNE IN 1992



AUGUST						
						1
2	3	4	5 ◑	6	7	8
9	10	11	12	13 ○	14	15
16	17	18	19	20	21 ◐	22
23 30	24 31	25	26	27	28 ●	29

AUGUST

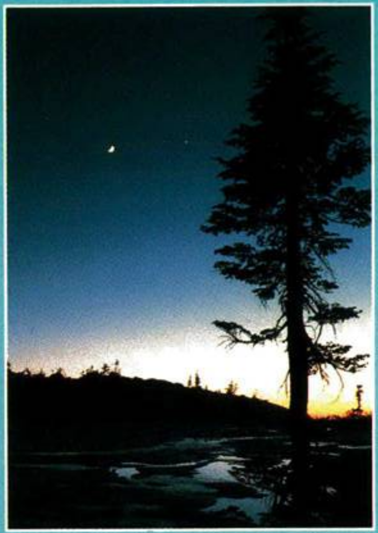
Day	Hour (UT)	
1	12	Jupiter 7° N. of crescent Moon (evening)
6	18	**Venus 1.1° N. of Regulus in Leo (evening)**
7	10	Saturn at opposition (rises at sunset)
10	10	Uranus 1.8° S. of gibbous Moon
	14	Neptune 0.8° S. of gibbous Moon
11	9	**Mars 5° N. of Aldebaran in Taurus**
12	9	Perseid meteors (Full Moon)
13	1	Saturn 5° S. of Full Moon
21	2	**Mercury at greatest elong. W. (morning)** *(best morning appearance for northern latitudes)*
	11	**Last Quarter Moon 2° S. of Pleiades**
22	21	Mars 1.4° S. of Moon (morning)
23	3	**Venus 0.3° N. of Jupiter (low in west)**
27	1	**Mercury 5° N. of crescent Moon (morning)**
29	19	**Venus 7° N. of crescent Moon (low in west)**

Events in **bold** are good astrophotography targets.

TWO BRIGHT PLANETS MEET

August is the last month to see Jupiter in the evening sky before it moves behind the Sun. Taking its place is brilliant Venus. This changing of the planetary guard is dramatically illustrated on the evenings of August 22 and 23 when Venus and Jupiter are less than 0.5° apart, much closer than the 1° to 2° that separated these two planets on their last meetings in June and October 1991. (Closest approach actually occurs at 3h UT on the 23rd.)

Though the closeness of this conjunction is striking, the two planets are very low in the western sky at sunset. From a latitude of 45° N., and with the Sun 6° below the horizon (the end of civil twilight), the pair is only 3° above the horizon. From 30° N. latitude under the same conditions, the two planets are about 6° up. But the fact that these are the two brightest planets in the sky make this conjunction worth looking for.

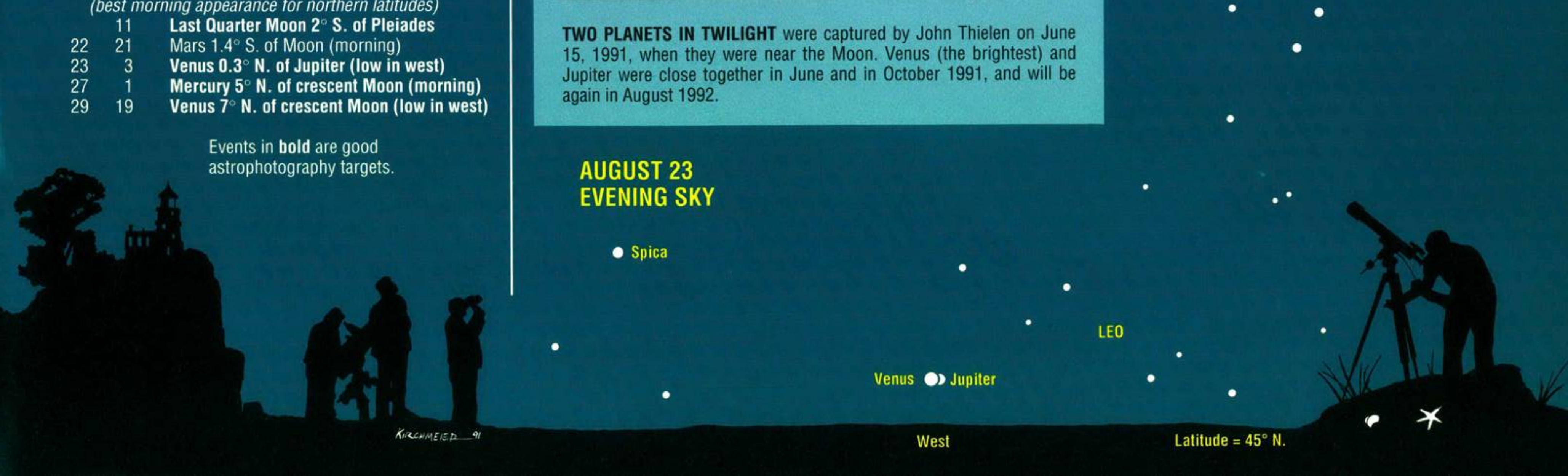


TWO PLANETS IN TWILIGHT were captured by John Thielen on June 15, 1991, when they were near the Moon. Venus (the brightest) and Jupiter were close together in June and in October 1991, and will be again in August 1992.

PLANETARY ENCOUNTERS IN 1992

Date	Hour (UT)	
Jan. 10	20	Mercury 0.6° N. of Mars
Jan. 29	21	Mars 0.4° S. of Uranus
Feb. 1	8	Mars 1.5° S. of Neptune
Feb. 7	7	Venus 0.9° N. of Uranus
Feb. 8	15	Venus 0.3° S. of Neptune
Feb. 19	**22**	**Venus 0.9° N. of Mars**
Feb. 29	**2**	**Venus 0.1° N. of Saturn**
Mar. 6	**13**	**Mars 0.4° S. of Saturn**
Apr. 5	23	Mercury 2° N. of Venus
July 25	15	Mercury 6° S. of Venus
Aug. 23	**3**	**Venus 0.3° N. of Jupiter**
Nov. 26	12	Venus 1.9° S. of Uranus
Nov. 27	13	Venus 3° S. of Neptune
Dec. 21	**16**	**Venus 1.1° S. of Saturn**

Events in **bold** are the most notable conjunctions of the year.



AUGUST 23
EVENING SKY

SEPTEMBER						
		1	2	3 ◐	4	5
6	7	8	9	10	11	12 ○
13	14	15	16	17	18	19 ◑
20	21	22	23	24	25	26 ●
27	28	29	30			

SEPTEMBER

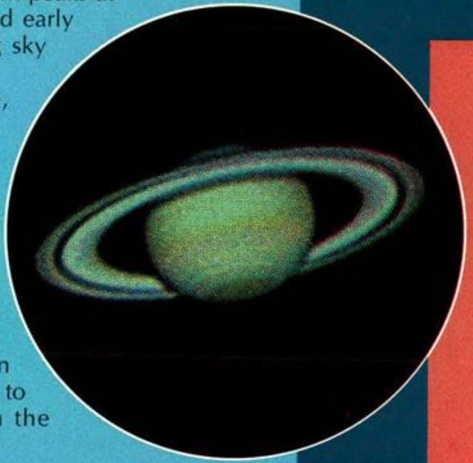
Day	Hour (UT)	
2	8	**Mars 1° N. of M1 in Taurus**
	23	**Mercury 1.2° N. of Regulus (morning)**
6	15	Uranus 1.9° S. of gibbous Moon
	19	Occultation of Neptune (Europe)
9	3	Saturn 5° S. of gibbous Moon
15	15	**Mars 1° S. of open cluster M35**
17	19	Jupiter in conjunction (behind Sun)
19	5	Venus 3° N. of Spica in Virgo (evening)
20	9	**Mars 0.9° N. of Last Quarter Moon**
22	17	**Crescent Moon 5° S. of open cluster M44**
	19	Autumnal equinox (autumn begins)
28	15	**Venus 4° N. of crescent Moon (evening)**

Events in **bold** are good astrophotography targets.

SATURN SHINES IN THE SUMMER AND FALL SKY

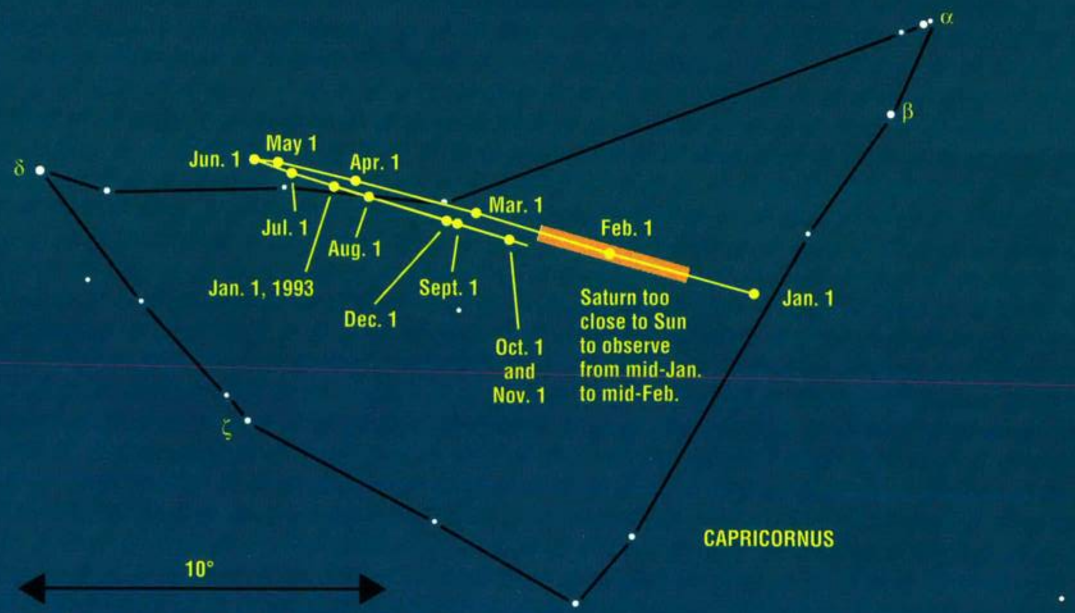
Jupiter is the star of the spring and early summer sky, but Saturn steals the show in late summer and autumn. Throughout 1992, Saturn stays within the boundaries of Capricornus, a constellation with no stars brighter than 2nd magnitude. During 1992 Saturn is always brighter than first magnitude, making Saturn the most prominent object in its part of the sky. (In fact, at its August 7 opposition date Saturn peaks at magnitude 0.2.) During late summer and early autumn look for Saturn in the evening sky above the southern horizon.

A glance through any telescope, however humble, reveals Saturn's rings. In March, at the start of the 1992 Saturn-observing season, the north face of the rings is tilted 19.5° to our line of sight. By year's end, the rings will have closed to 15.8°, heading for an edge-on appearance in 1995. Over the next few years Saturn will also creep up along the ecliptic, moving from its current southerly declination in the summer constellation of Capricornus to a maximum northerly declination in the winter constellation of Gemini in 2003.



SATURN IS BOTH STRIKING AND SUBTLE. Its rings are dramatic in any telescope, but seeing details on the planet itself requires steady seeing and a sharp eye. CCD image from 1991 by Don Parker using a 16-inch telescope and Spectra-Source LYNXX camera, with image processing and color compositing by Richard Berry.

SATURN'S PATH IN 1992



OCTOBER						
				1	2	3 ◐
4	5	6	7	8	9	10
11 ○	12	13	14	15	16	17
18	19 ◑	20	21	22	23	24
25 ●	26	27	28	29	30	31

OCTOBER

Day	Hour (UT)	
3	22	Uranus 2° S. of First Quarter Moon
4	2	Occultation of Neptune (N.W. Canada)
6	8	Saturn 5° S. of gibbous Moon
8	15	Draconid meteors (waxing gibbous Moon)
18	15	Mars 3° N. of Last Quarter Moon
21	13	Orionid meteors (waning crescent Moon)
25	—	Daylight Saving Time ends
27	15	**Occultation of Mercury (E. coast of N. America, daylight)**
28	15	**Venus 0.4° S. of Moon (occultation in S. Hemisphere)**
31	16	Mercury at greatest elong. E. (evening)

Events in **bold** are good astrophotography targets.

TWO PLANETS ENCOUNTER THE MOON

Two highlights of October are close passages of the crescent Moon past the two inner planets, Mercury and Venus. In fact, from some parts of the world, these planets are occulted by the Moon. Mercury's encounter on October 27 is visible as an occultation from parts of Europe, Africa, the Atlantic, and the Caribbean. Eastern North American observers can also witness Mercury's disappearance behind the Moon, but the feat will be challenging — the occultation occurs during broad daylight with Mercury and the Moon rising in the east.

The Venus occultation on October 28 is visible only from northern South America, the Atlantic, and Africa. North American viewers must be content with seeing one of the year's closest approaches of Venus and the crescent Moon, not a bad consolation prize.

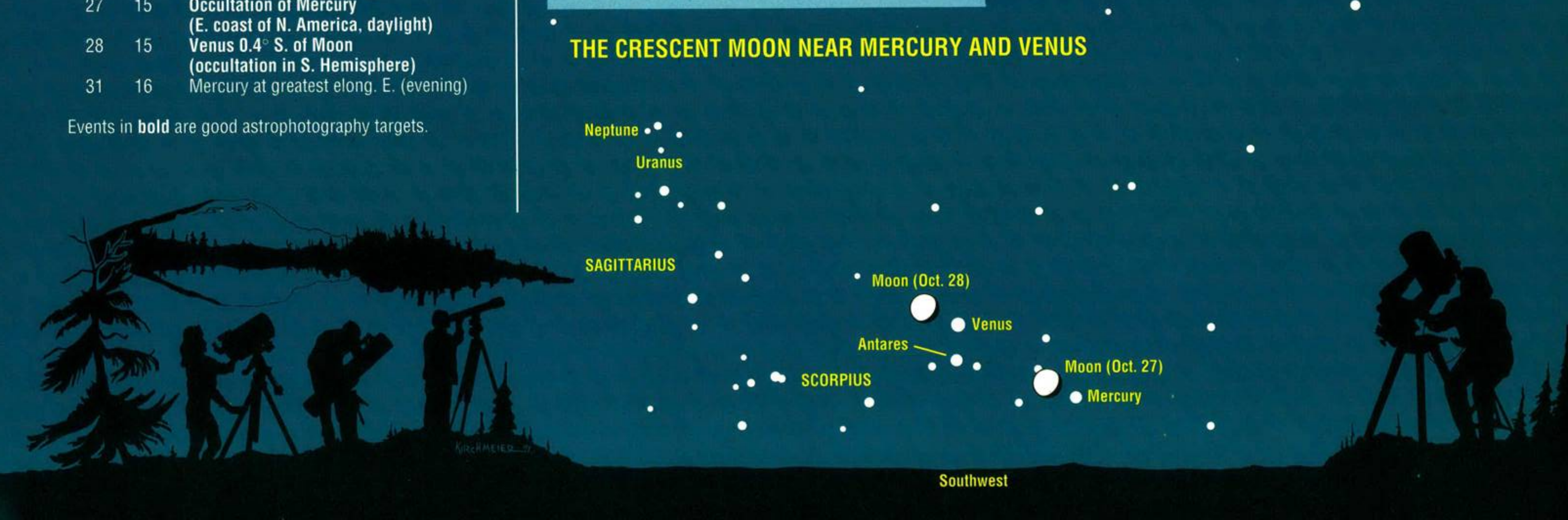
The Moon has a busy year occulting Neptune. Of the ten Neptune occultations in 1992, only the April 23 event occurs over the United States or southern Canada — but the event happens in daylight, making it impossible to see.

OCCULTATIONS OF PLANETS IN 1992

Date	Hour (UT)	
Jan. 3	10	Mars (Antarctica)
Jan. 31	17	Venus (Antarctica)
Feb. 1	9	Uranus (Europe, British Isles)
Feb. 1	12	Neptune (S. America, Africa)
Feb. 28	21	Neptune (Pacific)
Mar. 27	05	Neptune (Africa, Asia)
Apr. 23	**14**	**Neptune (N. America)**
May 20	21	Neptune (Asia)
June 17	4	Neptune (Europe)
July 14	9	Neptune (Pacific)
Aug. 10	14	Neptune (Asia)
Sept. 6	19	Neptune (Europe)
Sept. 20	9	Mars (Antarctica)
Oct. 4	**2**	**Neptune (N.W. Canada)**
Oct. 27	**15**	**Mercury (E. coast of N. America, daylight)**
Oct. 28	15	Venus (S. Hemisphere)

Events in **bold** are visible from North America.

THE CRESCENT MOON NEAR MERCURY AND VENUS



NOVEMBER						
1	2 ◐	3	4	5	6	7
8	9	10 ○	11	12	13	14
15	16	17 ◑	18	19	20	21
22	23	24 ●	25	26	27	28
29	30					

NOVEMBER

Day	Hour (UT)	
2	16	Saturn 5° S. of First Quarter Moon
	18	S. Taurid meteors (First Quarter Moon)
4	21	Mars 5° S. of Pollux in Gemini
15	12	Mars 5° N. of gibbous Moon
17	10	Leonid meteors peak (Last Quarter Moon)
20	16	Jupiter 7° N. of crescent Moon (morning)
26	12	**Venus 1.9° S. of Uranus (evening)**
27	13	**Venus 3° S. of Neptune (evening)**
	18	**Uranus 3° S. of crescent Moon (evening)**
	21	**Neptune 1.6° S. of crescent Moon (evening)**
	21	**Venus 5° S. of crescent Moon (evening)**
29	16	Mars stationary in Gemini
30	3	Saturn 5° S. of Moon

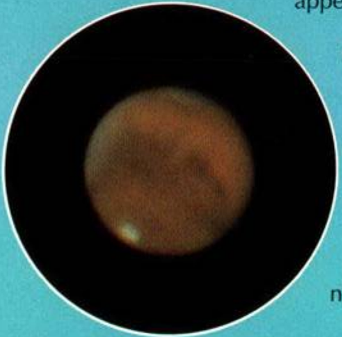
Events in **bold** are good astrophotography targets.

MARS APPROACHES EARTH

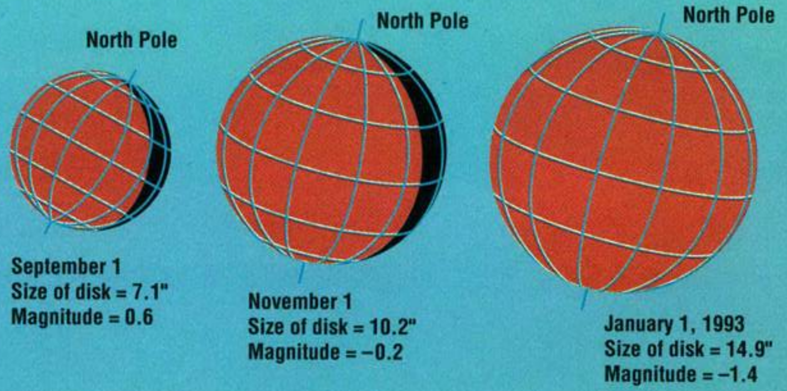
It's Mars observing season once again! Every two years Mars comes close to Earth, an occasion planet observers look forward to. It is only during these biennial close approaches (or "oppositions") that Mars appears large enough through a backyard telescope to show details on its ocher-hued disk.

Closest approach occurs on January 3, 1993, when Mars is 0.62 AU, or 57 million miles, away. At this approach we have the opportunity to see the north polar area, a part of Mars tipped away from us at the last few oppositions. The north pole will be tipped toward us at its maximum during the third week of November. At this time, spring is arriving in the Martian northern hemisphere. The north polar cap should be prominent but will be receding for the rest of 1992 and early 1993.

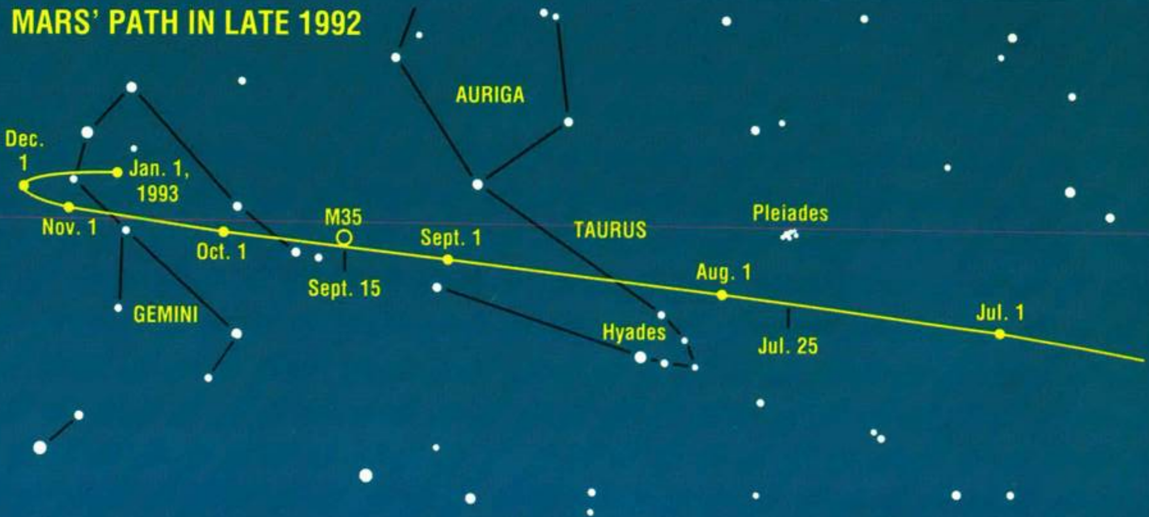
In late December 1992 and early January 1993, the Martian disk is about 15 arcseconds across at best — small, but because Mars will be high in the winter sky in Gemini it will be above the most turbulent layers of our atmosphere. This should make the disk of Mars look as sharp as possible and well worth exploring each clear night as 1992 comes to a close.



THE NORTH POLAR CAP of Mars should be the most prominent feature on the planet's disk in late 1992, unlike 1988 and 1990 when the south pole was tipped toward Earth. This 1988 photo records the south polar cap, the Meridiani Sinus markings, and a bluish haze on the morning limb of the planet. Photo by Don Parker.


North Pole
North Pole
North Pole
September 1
Size of disk = 7.1"
Magnitude = 0.6
November 1
Size of disk = 10.2"
Magnitude = −0.2
January 1, 1993
Size of disk = 14.9"
Magnitude = −1.4

MARS' PATH IN LATE 1992


AURIGA
Dec. 1
Jan. 1, 1993
M35
Nov. 1
Oct. 1
Sept. 15
Sept. 1
TAURUS
Pleiades
Aug. 1
Jul. 25
Jul. 1
Hyades
GEMINI

DECEMBER						
		1	2 ◐	3	4	5
6	7	8	9 ○	10	11	12
13	14	15	16 ◑	17	18	19
20	21	22	23	24 ●	25	26
27	28	29	30	31		

DECEMBER

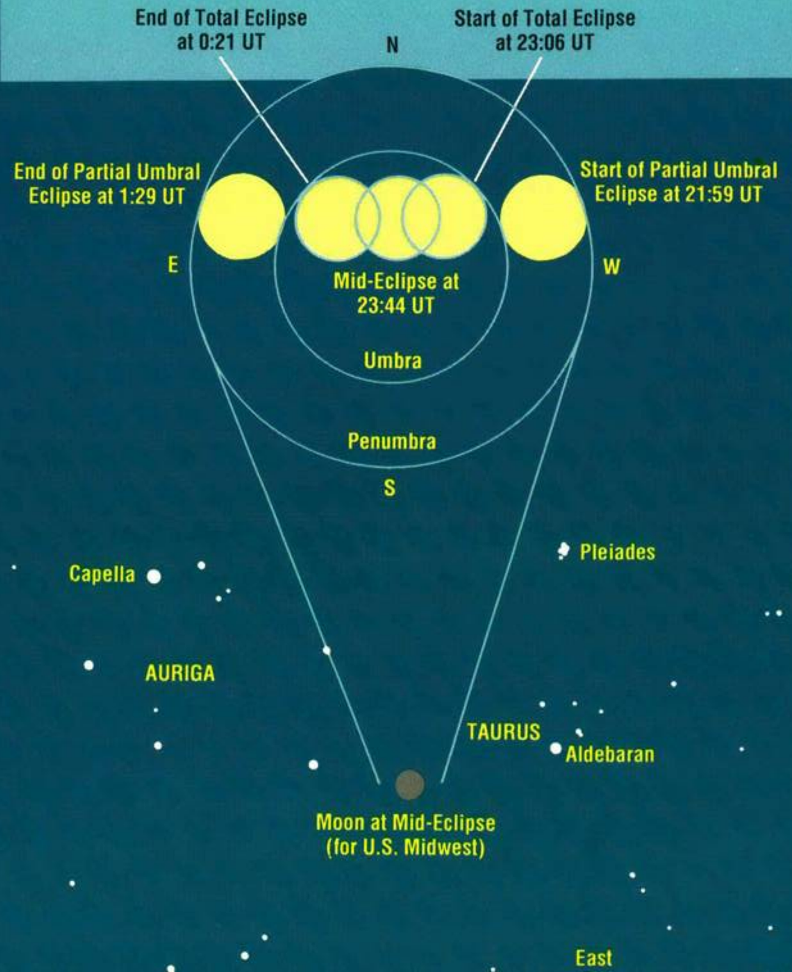
Day	Hour (UT)	
9	14	Mercury at greatest elong. W. (morning) *(good morning appearance for northern latitudes)*
10	0	**Total eclipse of the Moon (N. America)**
12	19	Mars 6° N. of nearly Full Moon
13	16	Geminid meteors (waning gibbous Moon)
18	5	Jupiter 7° N. of Moon
19	3	Mercury 6° N. of Antares (morning)
21	15	Winter solstice (winter begins)
	16	**Venus 1.1° S. of Saturn (evening)**
22	14	Mercury 1.5° N. of crescent Moon (morning)
	21	Mars 3° S. of Pollux in Gemini
23	—	Ursid meteors (New Moon)
24	1	**Partial eclipse of Sun (Japan)**
27	17	Saturn 6° S. of crescent Moon (evening)
28	2	Asteroid Juno at opposition
	7	**Venus 7° S. of crescent Moon (evening)**

Events in **bold** are good astrophotography targets.

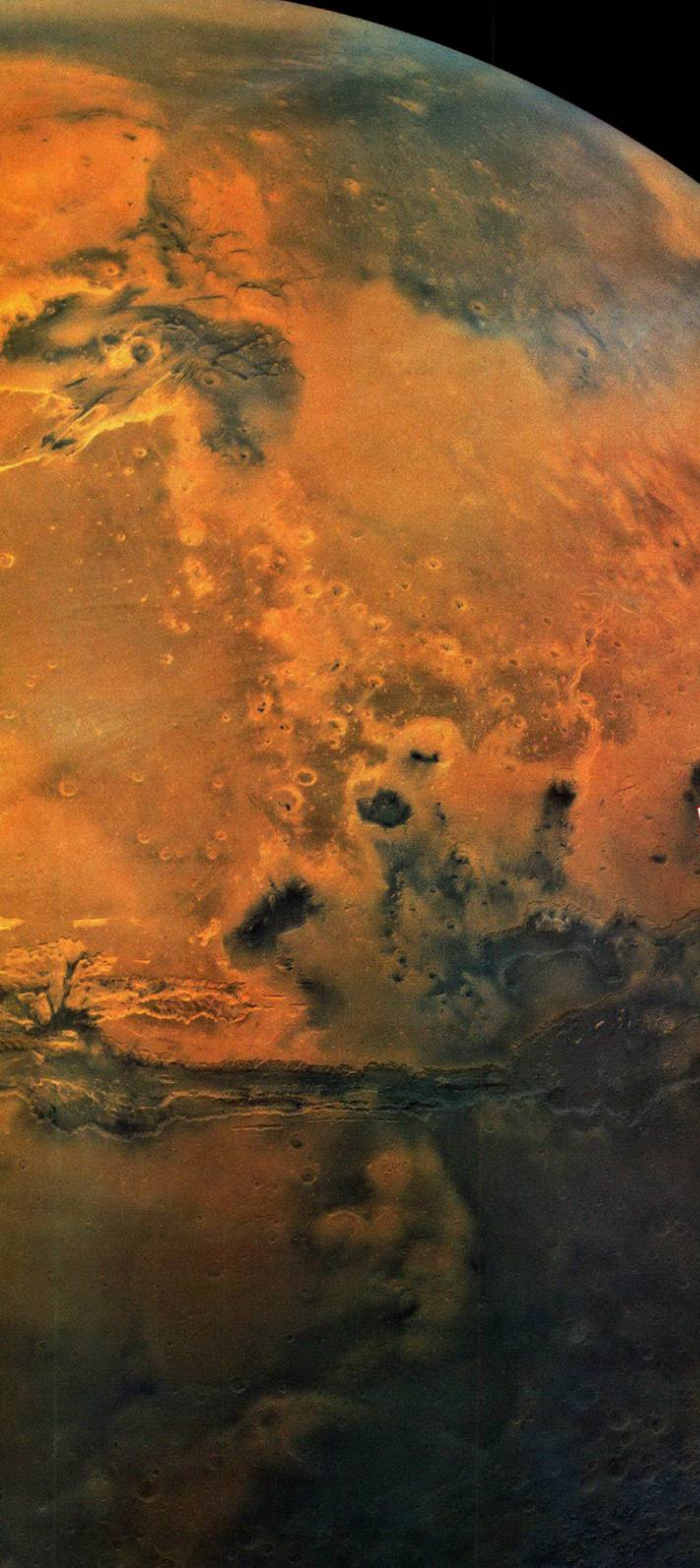
THE NIGHT THE MOON TURNS RED

The final big event of 1992 occurs on the night of December 9. It is the year's second eclipse of the Moon, this one a total, the first visible from North America since August 17, 1989. The Full Moon becomes completely engulfed by Earth's shadow and perhaps turns blood red. However, the coloration of the Moon during totality can vary from eclipse to eclipse. Sometimes the eclipsed Moon can appear dark gray, with little hint of reddish tint. This occurs when clouds or volcanic dust from a recent eruption fill Earth's atmosphere. Unfortunately, only the eastern half of North America sees the entire eclipse. Only from the east coast does the Moon rise before the partial umbral phase starts (at 4:59 p.m. Eastern Time). Observers in the central U.S. and mid-Canada see the Moon rise with the partial eclipse already in progress, but they do see all of totality. At mid-eclipse at 6:44 p.m. Eastern (5:44 p.m. Central) the Moon is in the eastern sky in Taurus. From the mountain states and provinces, totality is underway at moonrise, while from the west coast the Moon rises after the end of totality but with the Moon still in partial eclipse.

DECEMBER 9/10
TOTAL LUNAR ECLIPSE


End of Total Eclipse at 0:21 UT
N
Start of Total Eclipse at 23:06 UT
End of Partial Umbral Eclipse at 1:29 UT
Start of Partial Umbral Eclipse at 21:59 UT
E
W
Mid-Eclipse at 23:44 UT
Umbra
Penumbra
S
Pleiades
Capella
AURIGA
TAURUS
Aldebaran
Moon at Mid-Eclipse (for U.S. Midwest)
East

A BLOOD-RED MOON is often the result when the Moon passes completely into Earth's shadow as it will this month. Photo of the February 9, 1990 lunar eclipse taken from Finland by Lauri Mala.



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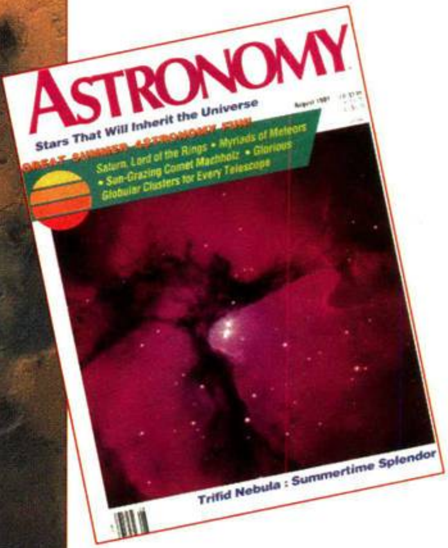
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